Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SEPTEMBER, 1955

SEP 27 1955
DETROIT
TECHNOLOGY DEPT.

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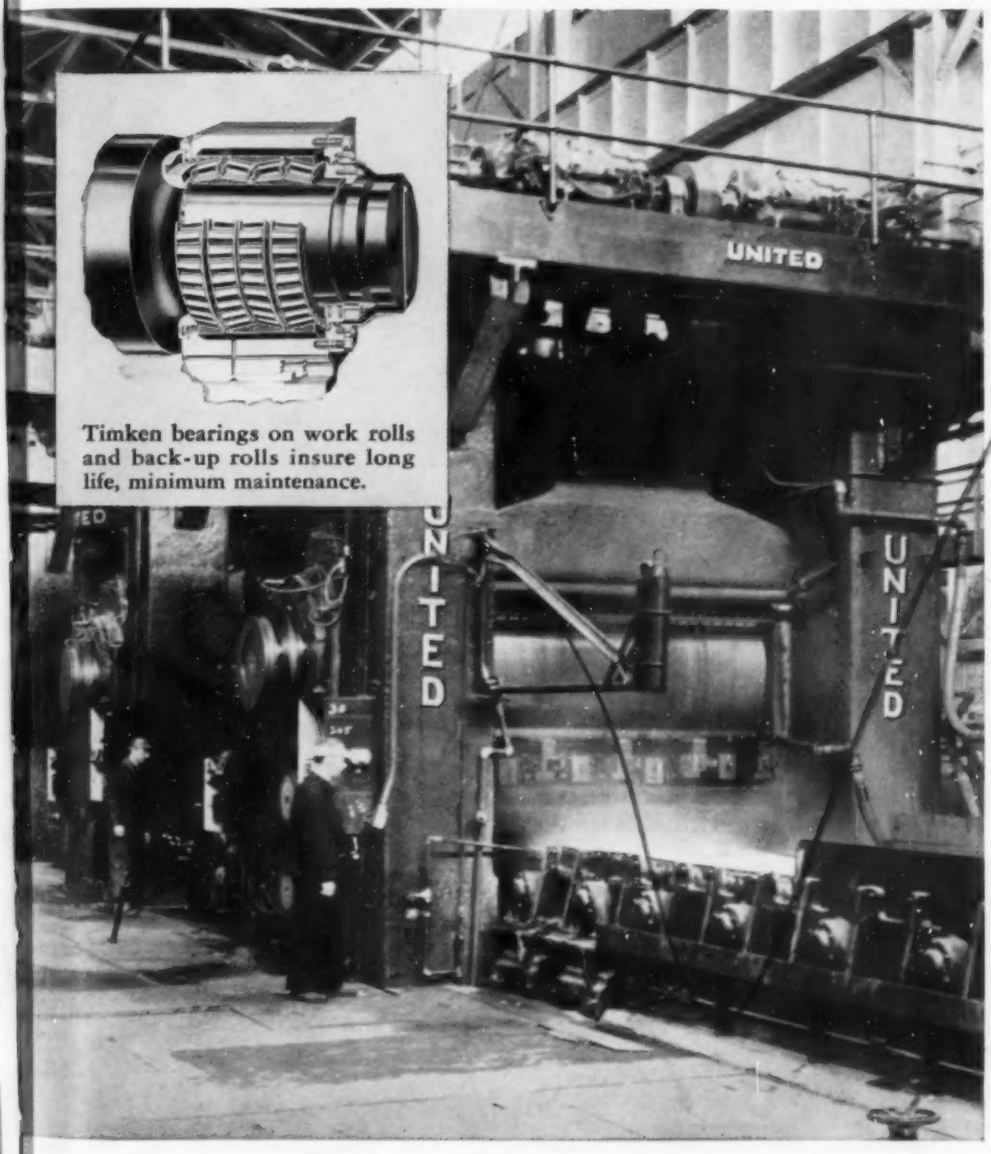
Records shattered! TIMKEN® bearings hit 8 million ton mark on this plate mill



Timken bearings on work rolls and back-up rolls insure long life, minimum maintenance.

THE 31 Timken® tapered roller bearings on this United semi-continuous plate mill at U. S. Steel's Homestead Works have now rolled an average of 5 million tons. And some of the Timken bearings have rolled over *eight million tons!*

One reason for this remarkable record is the high load capacity of Timken bearings. They carry the load on full lines of contact between races and rollers. A second reason is the extremely low frictional resistance of Timken bearings. They are geometrically designed to have true rolling motion and are manufactured to live up to this design.

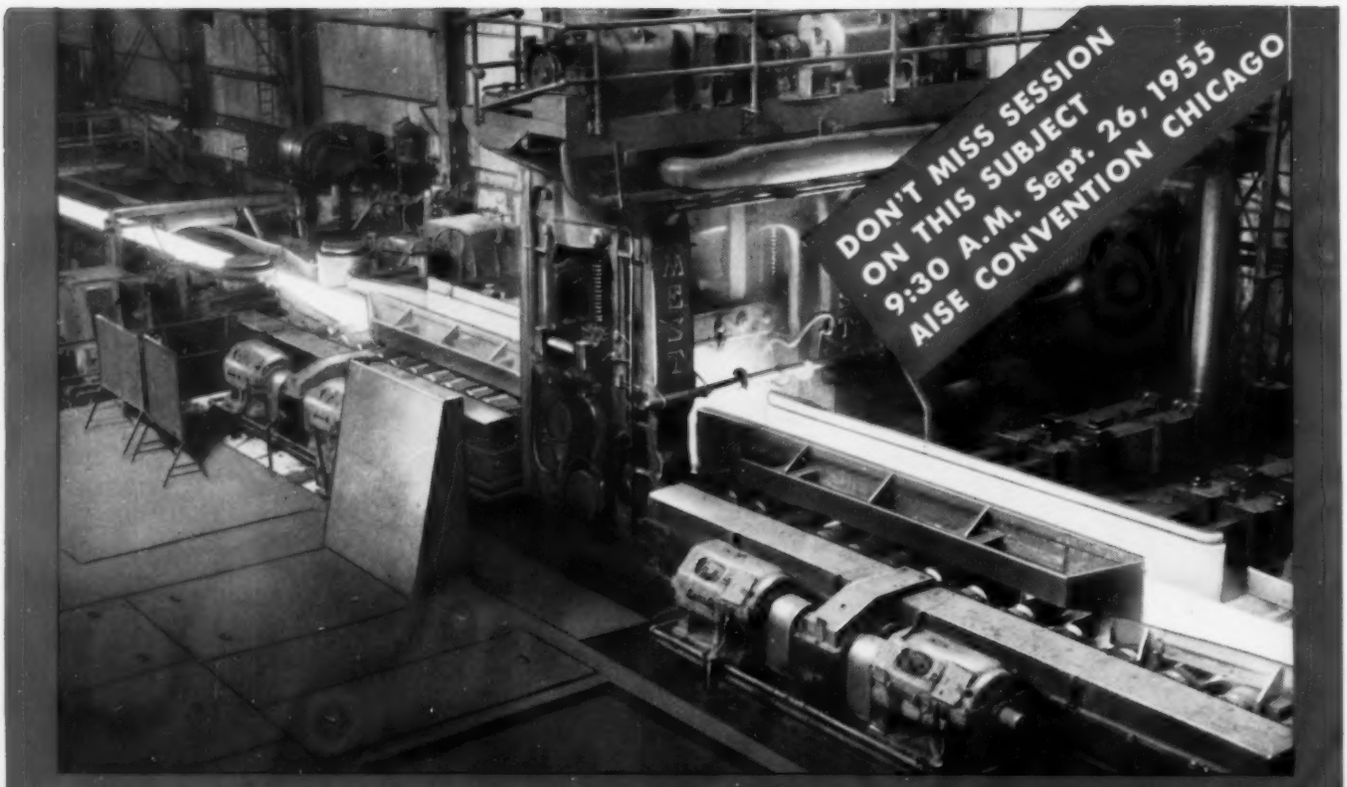
The design of rolling mills is simplified with Timken bearings because no extra thrust devices are required. Timken bearings take both radial and thrust loads. Thus chuck mountings are simpler and more compact. Timken bearings greatly simplify lubrication because they use grease—no tubes, pipes or reservoirs are needed.

Timken bearings make all kinds of machinery run better and last longer. When you buy or build machinery always look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL ⊙ AND THRUST ⊙ LOADS OR ANY COMBINATION ⊙



Outdated mill modernized— by low cost control redesign

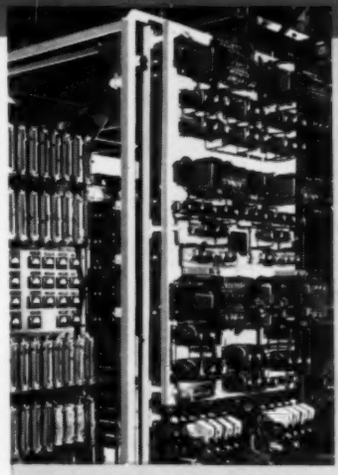
Timely engineering saves time, money and increases production

The 38" Blooming Mill above was built in 1928 to roll aluminum. In 1950, it was transferred to the Empire Steel Corp. works at Mansfield, Ohio, to roll steel slabs. This conversion to steel rolling service and the inherent increase in rolling horsepower required brought immediate problems. Mill reversal was sluggish, on the order of 4 seconds. The tremendous impact current inrush upon the generator, caused very unsatisfactory commutation.

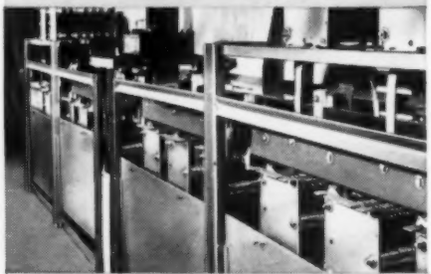
The Empire people considered several solutions. But they also consulted Cutler-Hammer, builder of the original electrical control for this mill. Cutler-Hammer recommendations were different, and simple, and accepted. Without change to the mill or its 5000 horsepower d-c motor, Cutler-Hammer replaced the 9-step, current-relay, rheostatic-type control with a voltage-regulating, current limiting magnetic amplifier, and added a permanent step of armature circuit resistance.

The results were "astonishing." "Down" time has been virtually eliminated. Reversal time has been cut from 4 seconds to 2 seconds. Current inrush during impact speed-drop has been cut almost 30%—to well within safe commutation limits. And the total cost of the tremendous performance improvement was only a fraction of the estimated cost of other solutions.

The tremendous scope and competency of Cutler-Hammer engineering ability, fostered by close contact with steel-mill problems ever since 1892, are available to you on any proposed mill installation. Typically, Cutler-Hammer gains the results you want by efficient application of sound engineering practices to produce electrical drives that install easier, work better, and last longer. For complete analysis of your control applications—look to CUTLER-HAMMER, Inc. . . . 1269 St. Paul Avenue, Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



Voltage-regulating, current-limiting magnetic amplifier provides smooth regulation during acceleration and deceleration. Its forcing action cuts reversal time to 2 seconds.



Permanent step of armature resistance compensates for electrical sluggishness of existing machines and with magnetic amplifier reduces impact speed-drop current inrush almost 30%.

CUTLER-HAMMER
MOTOR CONTROL
C-H

LOOK TO CUTLER-HAMMER MILL EXPERIENCE . . . AS BROAD AS IT IS LONG

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

can YOUR production equipment KEEP UP WITH THIS MARKET?

★ By 1965, the experts predict there will be 80 million automobiles in existence, as compared to some 50 million now.

For that traffic load, more than 50 billion dollars will be needed to rebuild the 3,350,000 miles of existing roads and to build new super highways.

Each million dollars of highways requires between 420 and 450 tons of steel. Each automobile averages about 3,500 pounds of steel, plus many pounds of copper, brass, aluminum, rubber and plastic.

Will you lose out competitively on this big market on poor quality of product or slow production equipment? Good equipment brings down production costs and improves product quality.

Aetna-Standard designs and builds equipment for producing, processing and fabricating steel, copper, brass, aluminum, rubber and plastic. Here is one example—an 80" Sheet Side Trimming and Shearing Line at the Fairless Works, U. S. Steel Corporation. Other Aetna major product lines include: Pipe Mills (Seamless and Butt Weld); Continuous Coating Lines; Rolls; Drawbenches; Machinery for Rubber and Plastic.

SUBSIDIARY and ASSOCIATED COMPANIES

The Aetna-Standard Engineering of Canada, Ltd., Toronto, Ontario, Canada.
The Head Wrightson Machine Company, Ltd., Middlesbrough, Eng.
Societe de Constructions de Montbard, Montbard, France.
Demag Aktiengesellschaft, Duisburg, Germany.
Compagnia Italiana Forme Acciaio, Milano, Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan.
Engineering and Development Corporation of the Philippines, Manila, P. I.
Hale and Kullgren, Inc., Akron, Ohio.
M. Castellvi, Inc., New York, N. Y.
Standard Engineering Co., Ellwood City, Pa.
Trans-World Traders, Inc., Pittsburgh, Pa.

Designers and Builders to the Steel, Copper, Brass, Aluminum, Rubber, Plastic and Chemical Industries

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

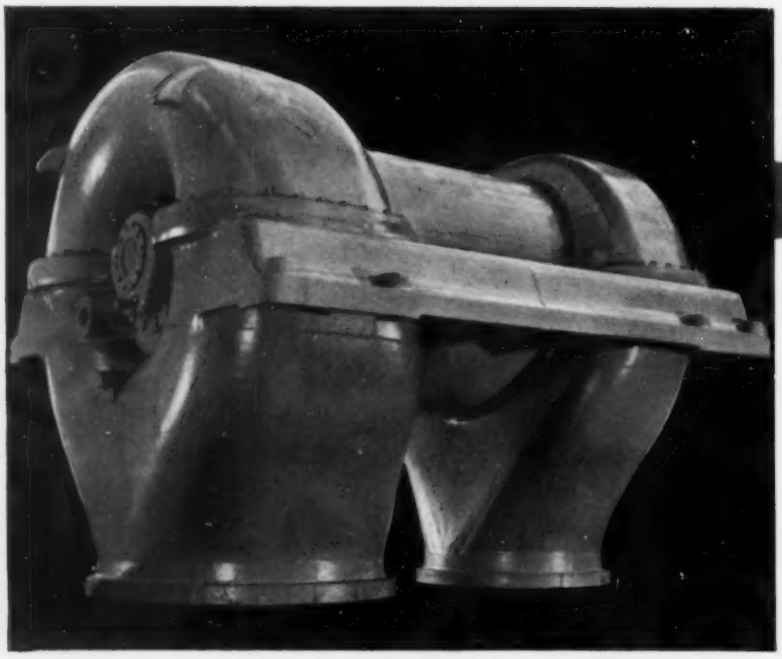
Aetna-Standard

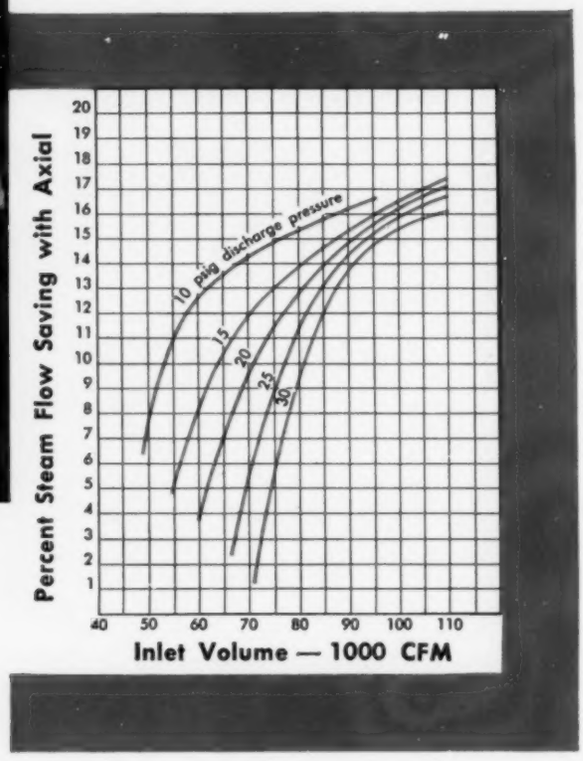
PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

Allis-Chalmers Axial Compressors for Blast Furnaces

Save 14-16% A Year on STEAM





In ratings over 100,000 cfm, save $50,000 to $70,000 per year on steam using Allis-Chalmers axial compressors in place of centrifugals

Here's why these savings are possible:

1 High Compressor Efficiency — A 110,000 cfm axial compressor requires 9.7% less horsepower due to inherent efficiency advantage. Air path of axial is nearly a straight line and losses from sharp turns (as in a multi-stage centrifugal blower) are eliminated.

2 High Turbine Efficiency — At 100,000 cfm and above, Allis-Chalmers axial compressor approaches optimum speed of 3600 rpm. A centrifugal blower of this rating operates at about 2600 to 2700 rpm. This higher design speed results in higher turbine efficiency—added steam flow economy for axial type.

This combination of efficiency factors means:

$50,000 to $70,000 yearly savings in steam used for the turbine drive . . . fast payoff.

In addition, the steam condenser required with an axial compressor is smaller because of lower steam requirements. Axial compressors are also smaller, easier to install. They require less floor space, smaller foundations than centrifugal blowers of the same rating.

Get complete facts. Allis-Chalmers is unbiased as a builder of both axial and centrifugal types. Call your nearby A-C office, or write Allis-Chalmers, Power Equipment Div., Milwaukee 1, Wis.

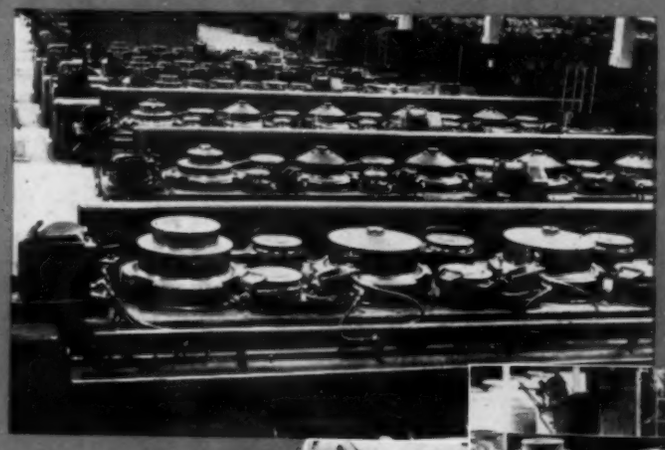
A-4831

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

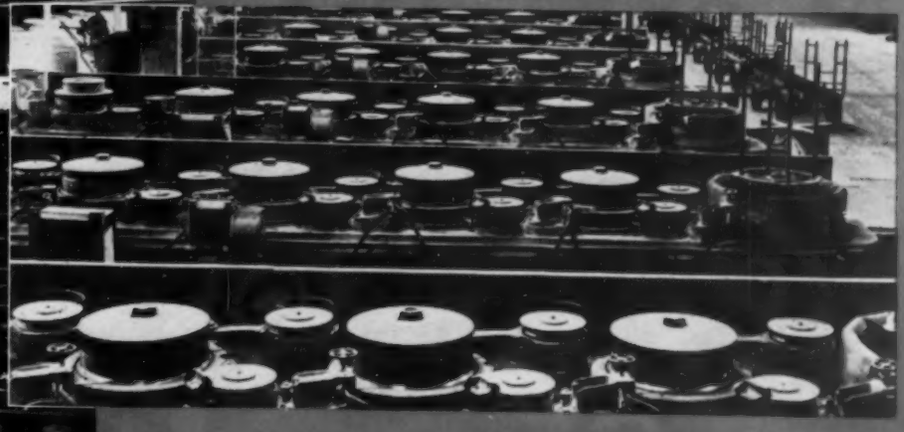
Wire BY THE CARLOAD OR THE TRAINLOAD

produced dependably at high rates by ... Vaughn®



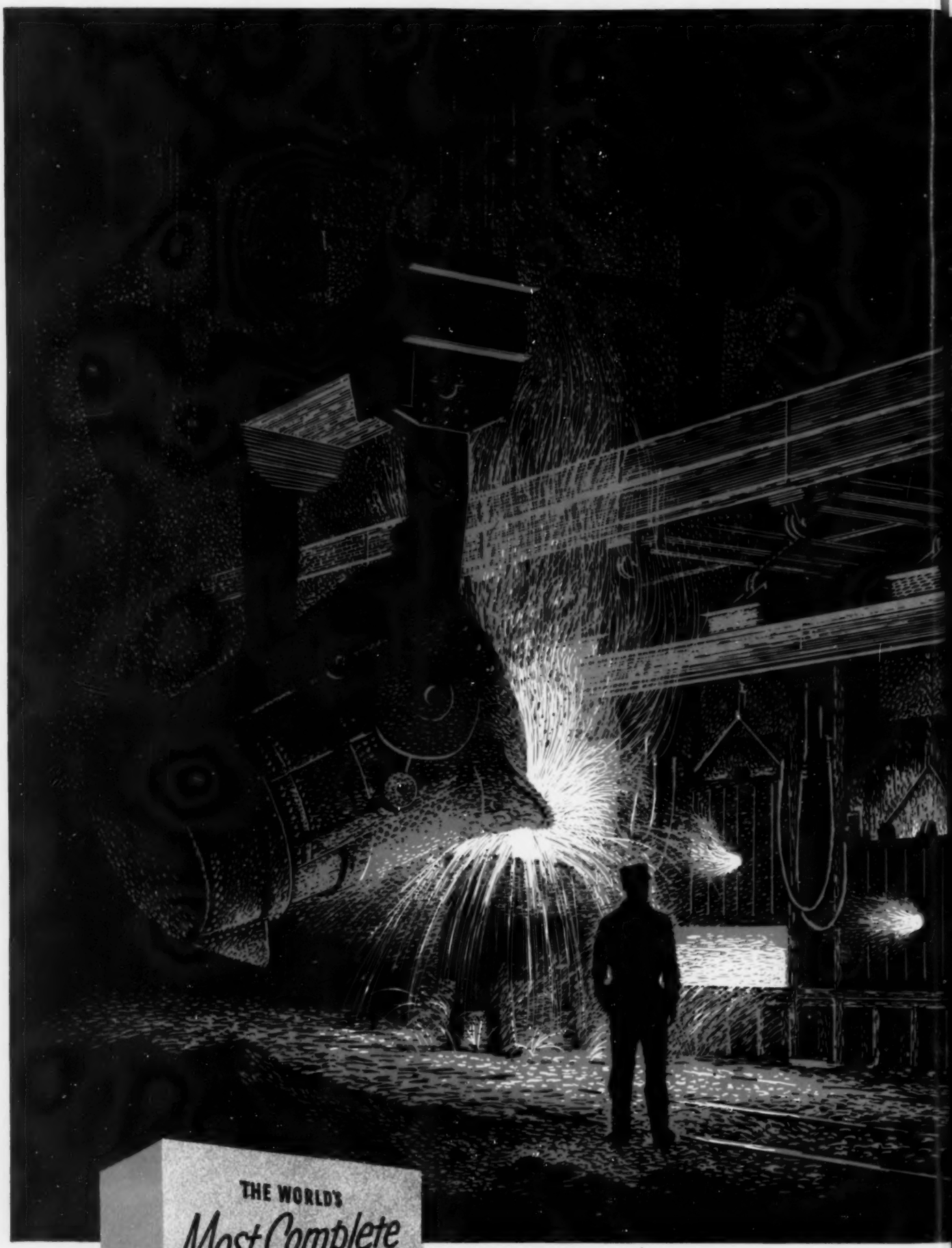
MOTOBLOX®

Let your high-volume needs in wire be matched by Vaughn Motoblox' high productivity! These famous machines meet quotas with quality—in speed and dependability. A Vaughn engineer will be happy to give you the facts, at your convenience.



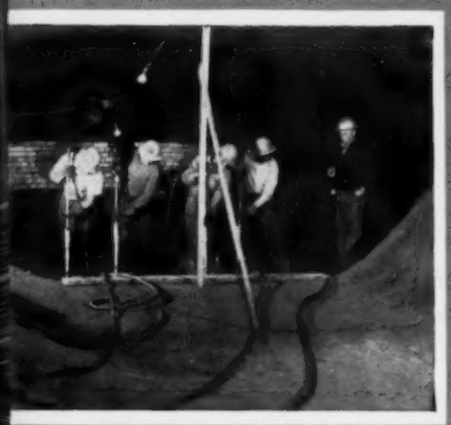
The VAUGHN MACHINERY COMPANY
CUYAHOGA FALLS, OHIO, U.S.A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.



HARBISON-WALKER
AND SUBSIDIARIES

Harbison-Walker



OPEN-HEARTH REFRACTORIES

help reduce steel-making costs

Open-hearth steel furnaces are industry's largest users of refractories. In these furnaces—in which by far the major portion of the world's steel is made—exceedingly severe and widely differing conditions call for refractories of highest quality and having particular combinations of physical and chemical properties. And here the use of Harbison-Walker products continues to reduce operating and maintenance costs.

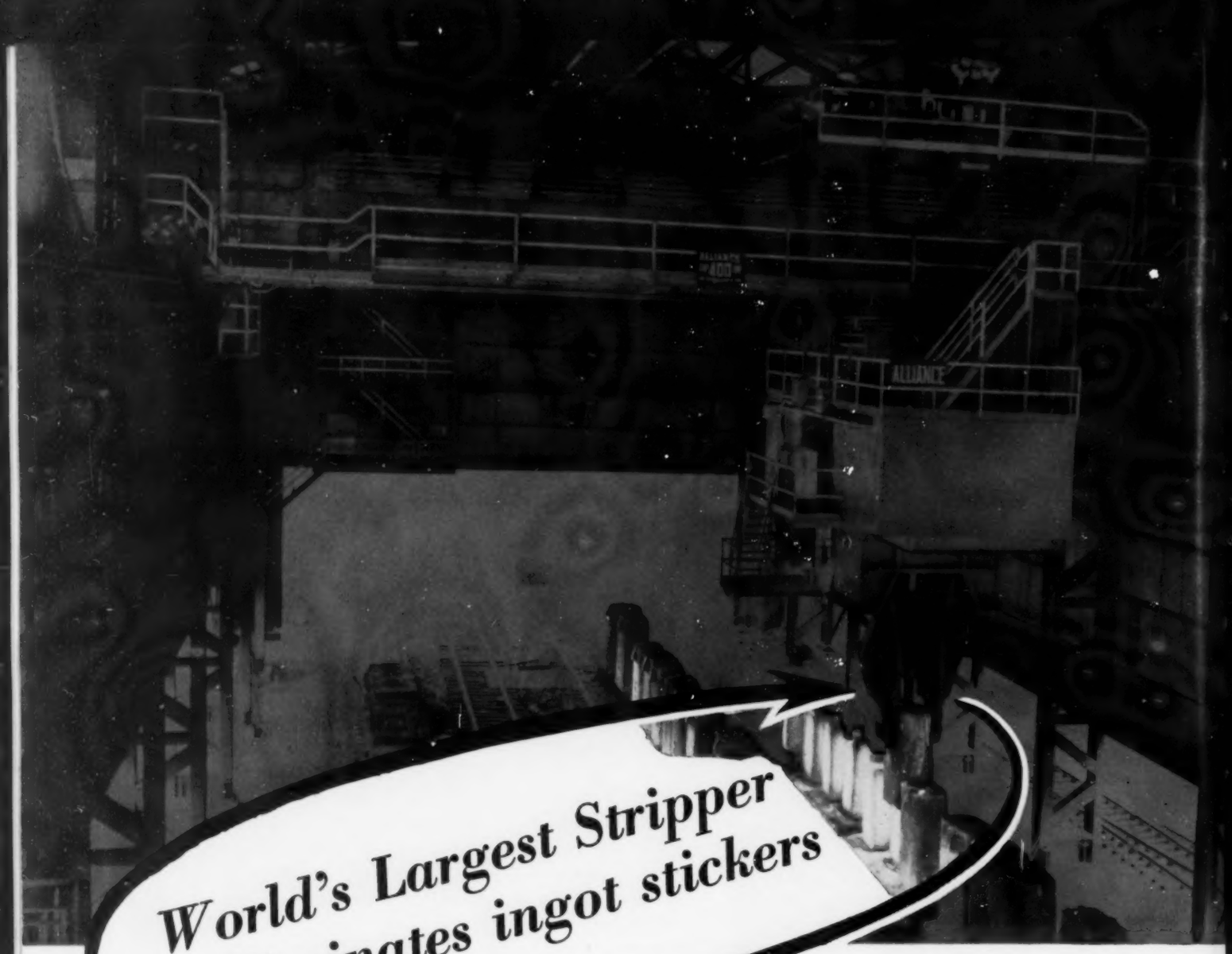
Among these refractories that give outstanding service are: H-W METALKASE, a metal-encased basic brick pioneered by Harbison-Walker; CHROMEX (chemically bonded) and CHROMEX B (extra hard fired) chrome-magnesite brick; STAR (conventional) and VEGA (the original super-duty) silica brick; H-W C MIX and H-W MAGNAMIX, superior monolithic materials for basic bottoms; FORSTERITE L and various other types and classes for regenerator checkers.

In addition, Harbison-Walker manufactures the full complement of types and classes of high alumina, fire clay and insulating fire brick, and the complete range of castables and plastic refractories for every application.

Technical service based on the most extensive experience and research is freely offered for assistance in determining the refractories best suited for each specific requirement.

REFRACTORIES COMPANY

World's Largest Producer of Refractories • General Offices—Pittsburgh 22, Pa.



World's Largest Stripper eliminates ingot stickers

The big 400-ton, push-pull, low head room, screw-type Alliance Stripper Crane is equipped with a stripping mechanism that exerts 2½ million pounds of pressure to smoothly strip moulds from ingots. What's more, a retractable bull nose and gripping tongs enable a single operator to make all necessary adjustments to strip either large end-up or small end-up ingots. These special Alliance-engineered features eliminate stickers, make possible tremendous savings in time, moulds and costly alloy ingots.

Alliance . . . world's largest builder of the world's largest cranes . . . makes a habit of offering industry greater strength and lifting versatility. Our big strippers, built with a name plate rating of 400 tons and overload rating of 1200 tons, embody many other exclusive features of design:

- ★ **Special electrical counterweight (counter torque device) developed by The Alliance Machine Company which prevents ingots from falling and inflicting damage to buggies.**
- ★ **No slack cable during stripping operation.**
- ★ **Eliminates the heavy and hazardous counterweights formerly used.**
- ★ **By means of a unique lubricating device, the ample size bronze nut gives many years of trouble-free service.**
- ★ **Special system of spiral bevel and single helical gears results in smoother operation.**
- ★ **All gears are enclosed and run in oil.**
- ★ **Cab that provides the operator with maximum visibility and safety.**

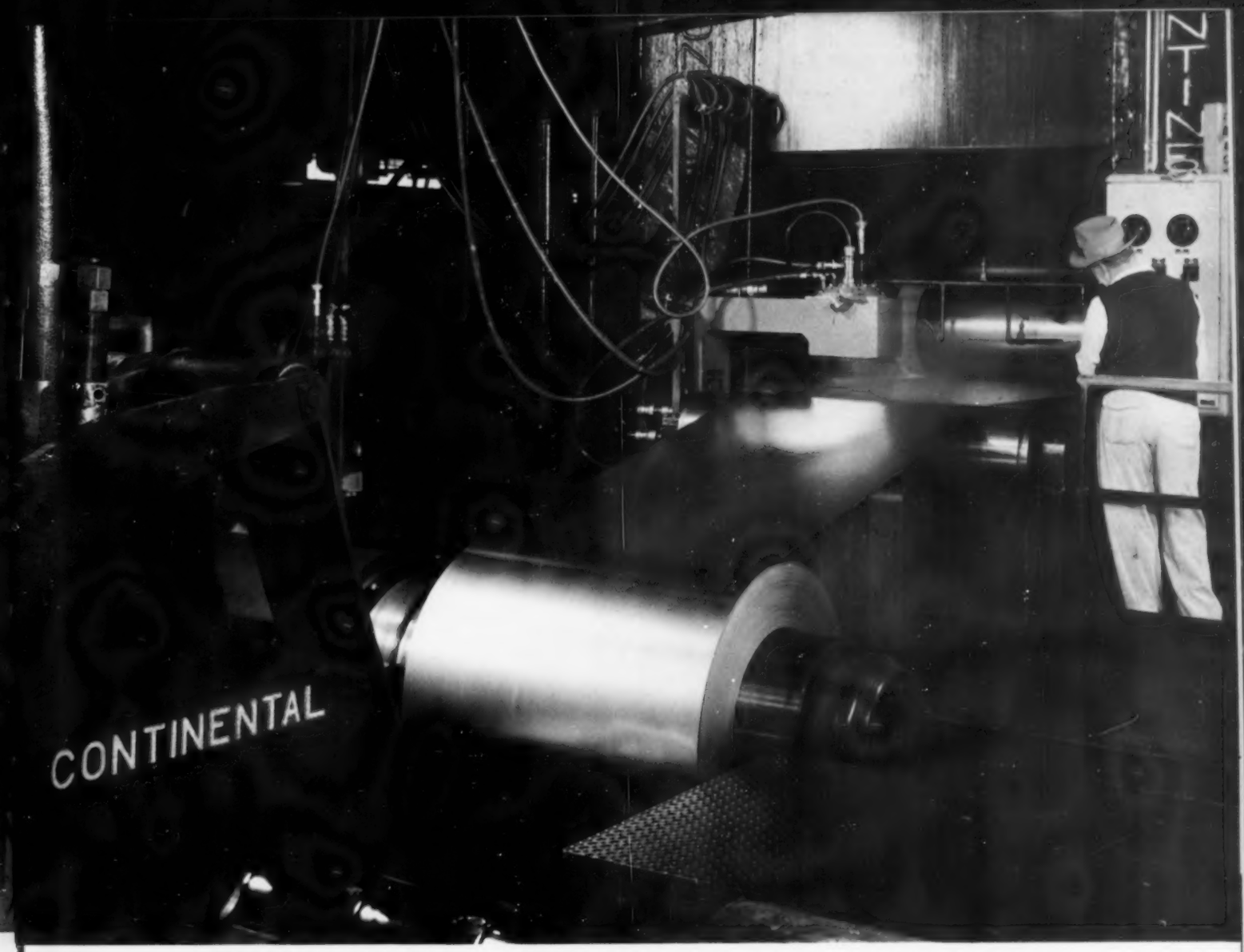
These and many more features are the reasons why it pays to consult Alliance if you're planning for more, newer and better lifting power for your plant. Write today for an analysis of your specific needs.

THE *Alliance* MACHINE COMPANY

World's largest builders of world's largest cranes

MAIN OFFICE
ALLIANCE, OHIO • PITTSBURGH OFFICE **1622 OLIVER BUILDING, PITTSBURGH, PA.**

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION



PART OF THE 100 million dollar expansion by McLouth Steel Corporation, this CONTINENTAL 60-inch, 4-stand tandem cold mill is now in full operation at McLouth's new Gibraltar Plant.

For the automotive industry:

THE SMOOTHEST STEEL POSSIBLE

DID YOU EVER watch a man buy a new car? First, he sits in it. Then he test drives it. But the crucial test comes when he steps back and *looks* at the car. Let there not be the slightest imperfection in the finish at this point. To provide this glistening smooth finish the auto makers must start with steel of the highest quality.

McLouth Steel Corporation sells most of its steel for use in automobiles, so they are sticklers for quality. And that was their chief concern when they began buying cold rolling equipment for their brand new 20-million-dollar Gibraltar Plant.

They chose CONTINENTAL to design and build the new 60-inch 4-stand tandem cold mill, and the two 60-inch temper mills.

Why? Because they could be sure of CONTINENTAL quality—had used CONTINENTAL equipment for years at their Trenton plant. And further, they knew CONTINENTAL would design the mill equipment specifically to meet the needs and requirements of the layout for the Gibraltar Plant. These mills are now installed and turning out the high quality cold rolled steel which is produced by McLouth.

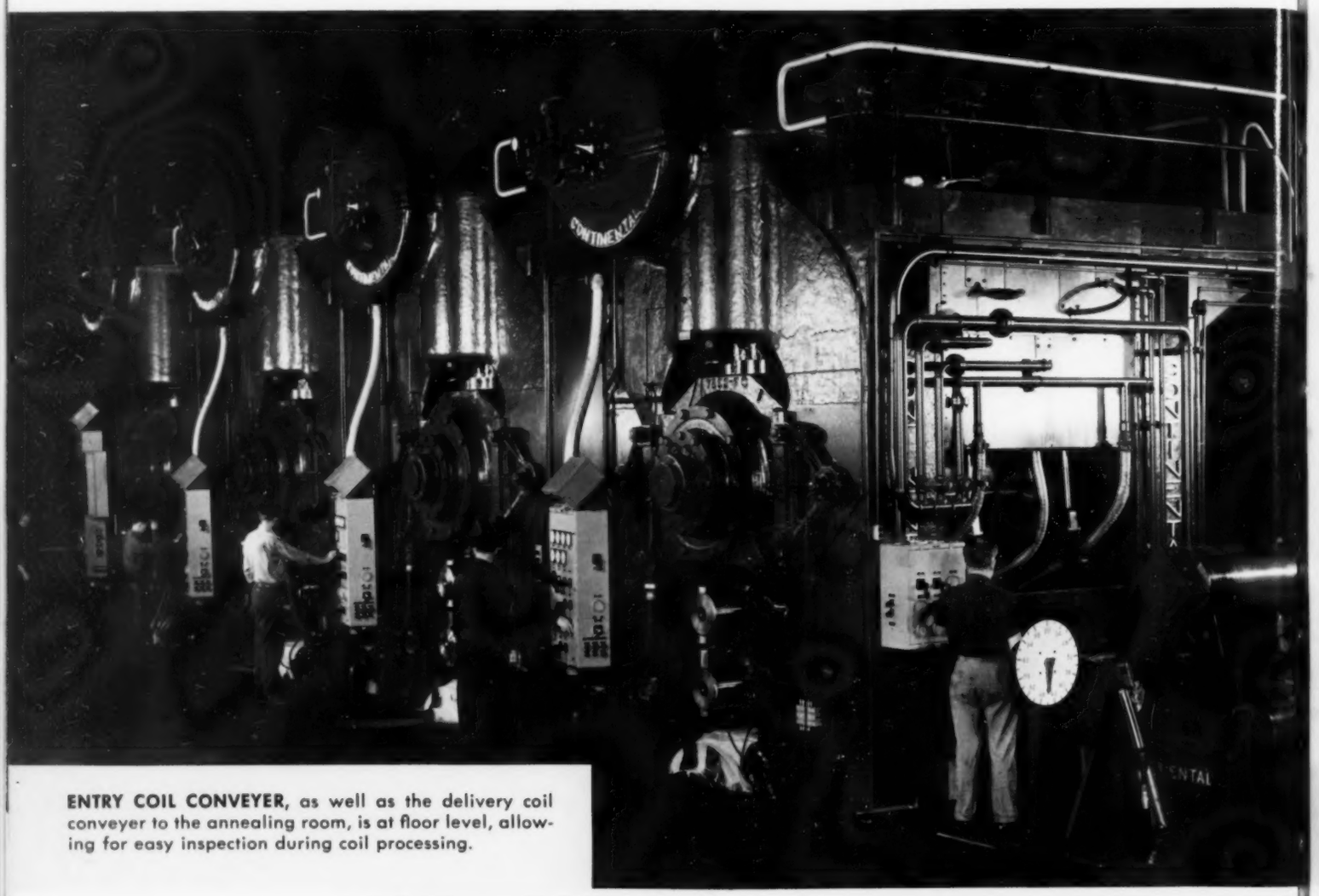
CONTINENTAL

CONTINENTAL
Foundry & Machine
Company

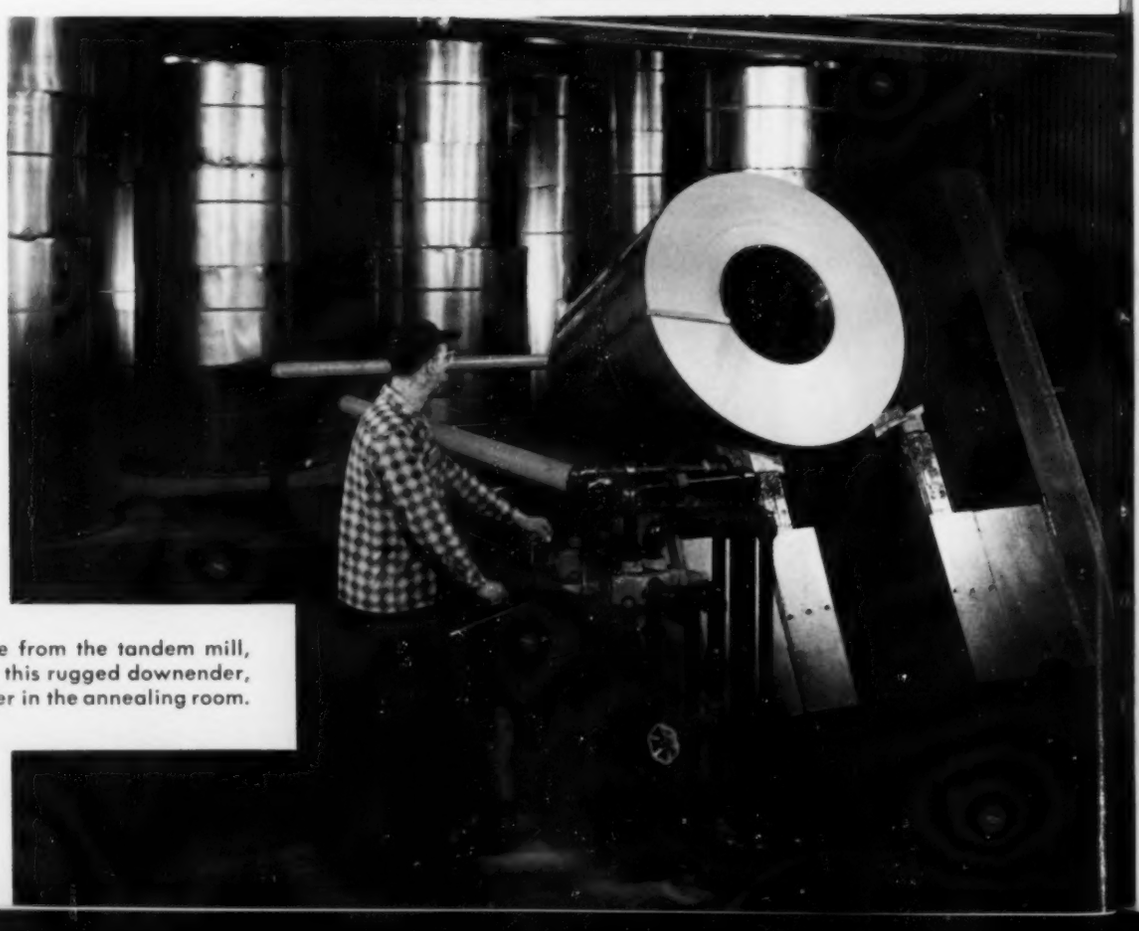
Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
General Offices: 144 Railroad St., East Chicago, Indiana
***Plants at* East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.**
***Copes-Vulcan Division*, Erie, Pa.**

continued on next page

BUILT . . . INSTALLED . . .



ENTRY COIL CONVEYER, as well as the delivery coil conveyer to the annealing room, is at floor level, allowing for easy inspection during coil processing.



COILS, delivered at right angle from the tandem mill, are transferred at floor level to this rugged downender, then to another transfer conveyer in the annealing room.

and PRODUCING

...for McLouth Steel Corporation

MANY FEATURES of this CONTINENTAL mill were custom designed to suit the layout of the new Gibraltar Plant of McLouth Steel Corporation. Here are a few of these special features:

All coil conveyors, both entry and delivery, are at floor level providing an unbroken floor in the immediate vicinity of the mill equipment. This arrangement allows easy inspection of all the coils during processing.

In full cooperation with the electrical supplier, the electrical installation is contained in cable raceways in the mill equipment. This simplifies the installation and provides easy access for maintenance.

The entry coil conveyor provides ample raw coil storage and is loaded by overhead crane. The delivery coil conveyor receives the coils at right angles to the mill and delivers them to the annealing area, via a downender.

CONTINENTAL custom designs every rolling mill it makes, takes full charge from preliminary design to final satisfactory operation, designs and builds all the auxiliaries you need.

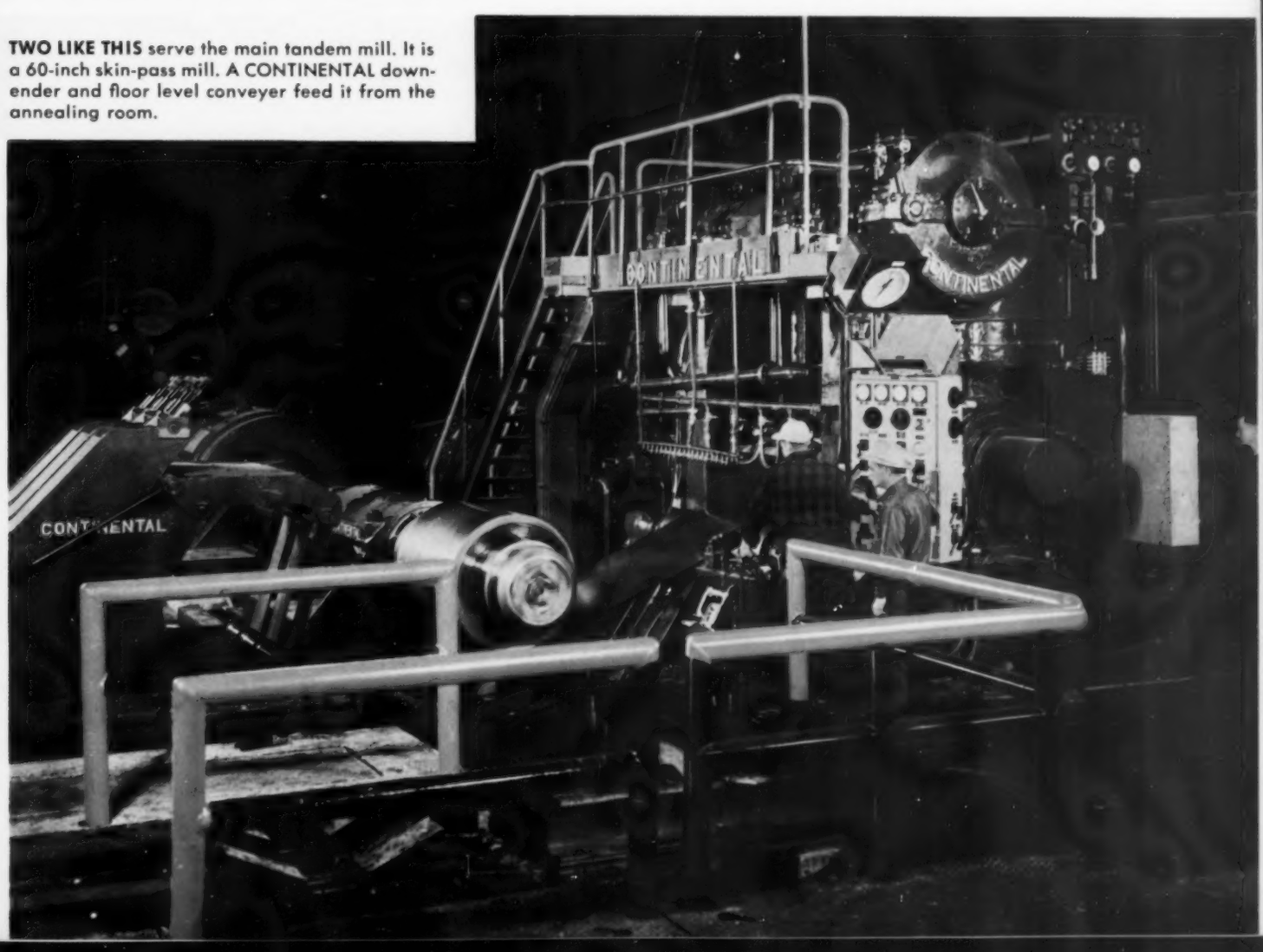
In addition to all types of steel rolling mills, CONTINENTAL makes rolls, roll lathes, steel processing equipment, boiler cleaning and control equipment, castings, weldments. Production facilities in both the Pittsburgh and the Chicago areas.

CONTINENTAL
Foundry & Machine Company

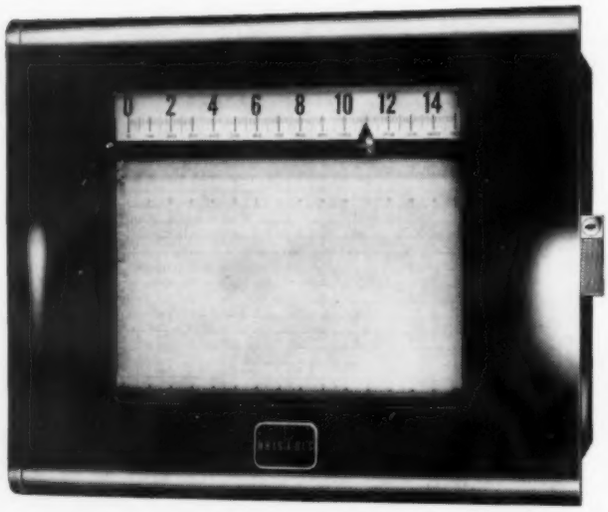
CONTINENTAL

Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
General Offices: 144 Railroad St., East Chicago, Indiana
***Plants at* East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.**
***Copes-Vulcan Division*, Erie, Pa.**

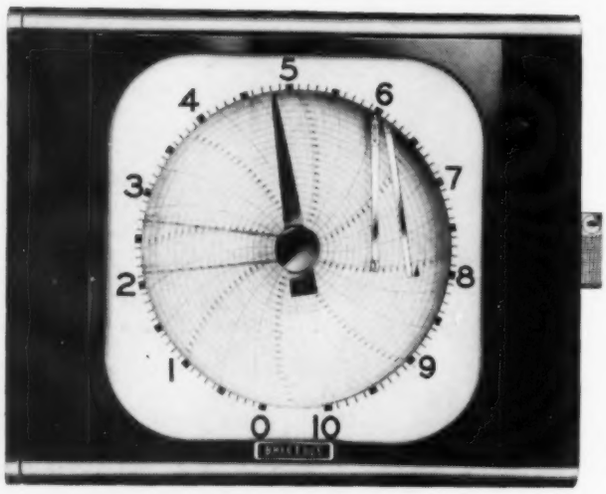
TWO LIKE THIS serve the main tandem mill. It is a 60-inch skin-pass mill. A CONTINENTAL downender and floor level conveyer feed it from the annealing room.



WHAT'S NEWS AT BRISTOL . . .



Three reasons temperature control is better with Bristol

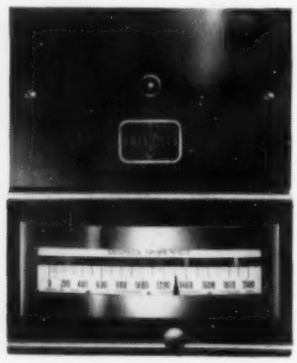


FIRST TWO REASONS are Bristol's Electronic Dynamaster Potentiometers with strip chart or round chart. Here's why:

No-Batt Continuous Standardization in these instruments eliminates need for dry cells. Result: No interruption in operation for standardization, no batteries to replace.

Recorders for every requirement – single-pen, two-pen, and multiple-record (up to 24 points)

Electric and pneumatic controllers for every furnace and oven control mode, including *electric controllers* for on-off, proportional-input, 3-position, proportional, proportional plus automatic reset, and time-program control; and *pneumatic controllers* for on-off, proportional, proportional plus reset, and proportional plus reset plus derivative control.



THIRD REASON: Bristol's Free-Vane® Electronic Pyrometer Controller. No relay chatter with this controller! Bristol's thyratron-operated relay puts a stop to that. Minute changes in temperature – less than 0.003" on scale – close or open the relay with positive trigger action. Available in thermocouple and radiation pyrometer controllers in ranges up to 4000F. New high-torque, rugged millivoltmeter gives greater accuracy and a sensitivity of 15 ohms per millivolt. Separate plug-in control units, variety of control modes available.

Get the whole story on these three rugged Bristol Furnace and Oven Controls. Write for free 48-page Bulletin P1260 today. It contains specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn.

5.40

BRISTOL

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

SEE RUST-OLEUM APPLIED DIRECTLY OVER SOUND RUSTED SURFACES! MAKE THIS TEST UNDER YOUR OWN CONDITIONS AND SEE PROOF OF PERFORMANCE!

See Rust-Oleum 769 Damp-Proof Red Primer actually applied over a badly rusted surface after simple scraping and wire-brushing to remove rust scale and loose rust in the Rust-Oleum *"rusted panel demonstration."* Rust-Oleum's specially-processed fish oil vehicle *penetrates* rust to bare metal usually eliminating sandblasting and other costly surface preparations.

Rust-Oleum finish coatings in Aluminum, Green, White, Gray, Yellow, Black, Orange, Blue and others provide both *Rust Prevention* and *Decorative Beauty!* Specify Rust-Oleum for new construction, maintenance, and re-modeling. See Sweets for complete catalog and nearest Rust-Oleum Industrial Distributor, or attach coupon to your business letterhead.

RUST-OLEUM®

STOPS RUST!

There Is Only One Rust-Oleum. It Is Distinctive as Your Own Fingerprint. Resists Rain, Sun, Fumes, Snow, Heat, Salt Air, Salt Water, etc.

See local classified telephone directory under Rust Preventives or Paints for nearest Rust-Oleum Industrial Distributor.

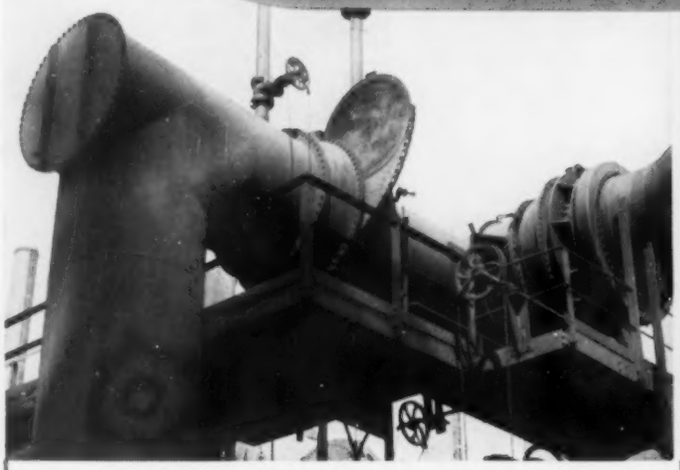
ATTACH TO YOUR BUSINESS LETTERHEAD AND MAIL TO:
Rust-Oleum Corporation, 2442 Oakton St., Evanston, Ill.

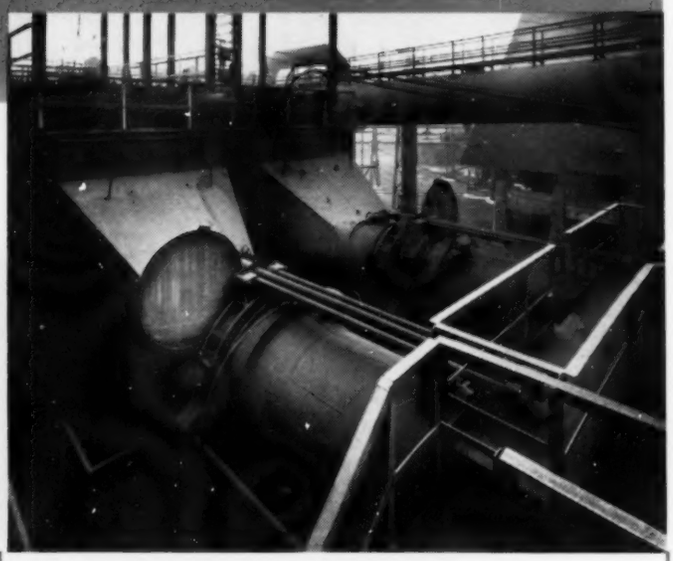
- ☐ Please Show Me the Rust-Oleum "Rusted Panel Demonstration."
- ☐ Test Application of Rust-Oleum Over Rusted Metal Surfaces in My Plant.
- ☐ Complete Literature with Color Chart.
- ☐ Nearest Rust-Oleum Industrial Distributor.

Industrial Gas Mains 6″ to 120″ ... are best controlled by

Bailey GOGGLE VALVES

PROVED SAFE AND EFFICIENT ON GAS WASHERS, BLAST FURNACE MAINS, PRECIPITATORS, BOILER PLANTS





Mechanical Type

By means of a powerful clamping force applied equally at all points around the disc periphery, the Bailey Mechanical Goggle Valve provides a safe, tight seal for gas mains from 6″ to 72″ in diameter. The goggle plate is freed instantly by the same powerful mechanism, regardless of the length of time between operations. Both this type and Bailey Thermal Expansion Valves require only a minimum of maintenance.

Thermal Expansion Type

Designed for gas mains from 36″ to 120″, the Bailey Thermal Expansion type goggle valve operates by the linear expansion and contraction of three sets of steel tubes. When steam is applied, the tubes expand and separate the flanges, thereby freeing the goggle plate for swinging to open or closed position. When steam is removed, normal cooling contracts the tubes, which then clamp the flanges together to form a gas-tight leakproof seal. Can be hand-operated in case of steam failure.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA.

MEET *All* REQUIREMENTS

... *correct* OHMIC VALUES

... *plus* AMPLE CAPACITY

P-G *Steel Grid Resistors*

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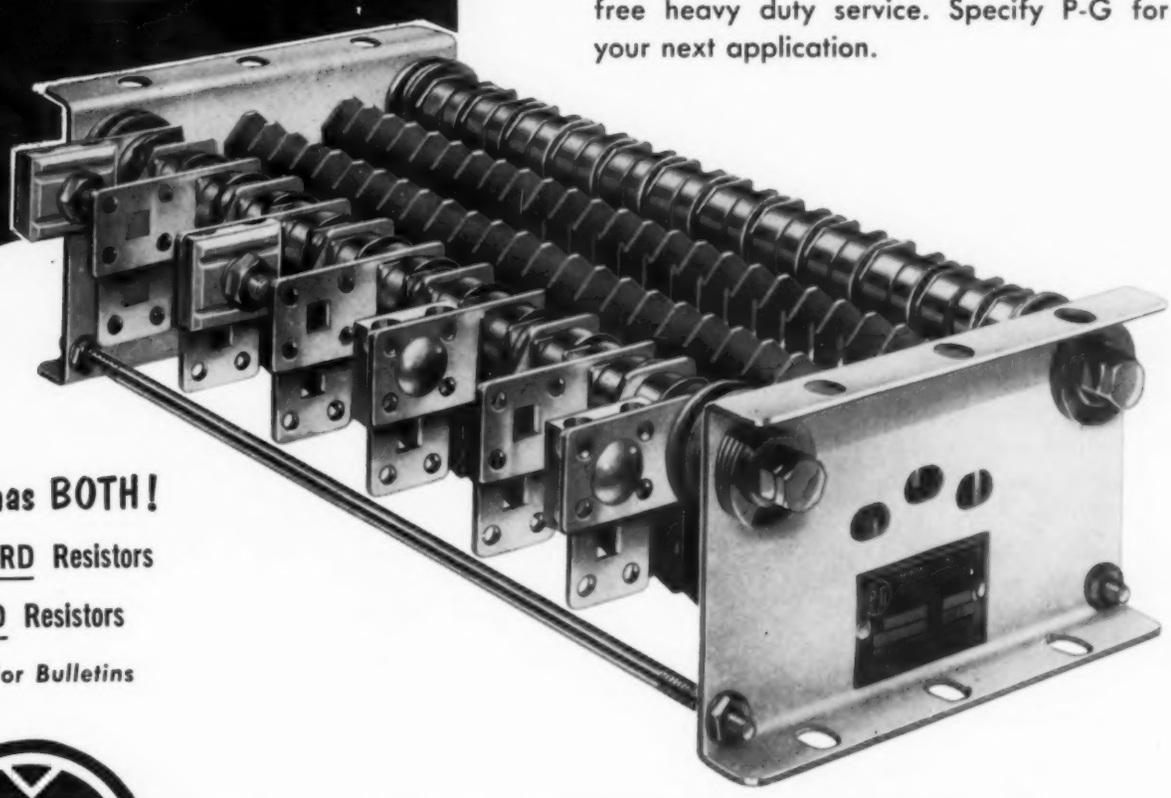

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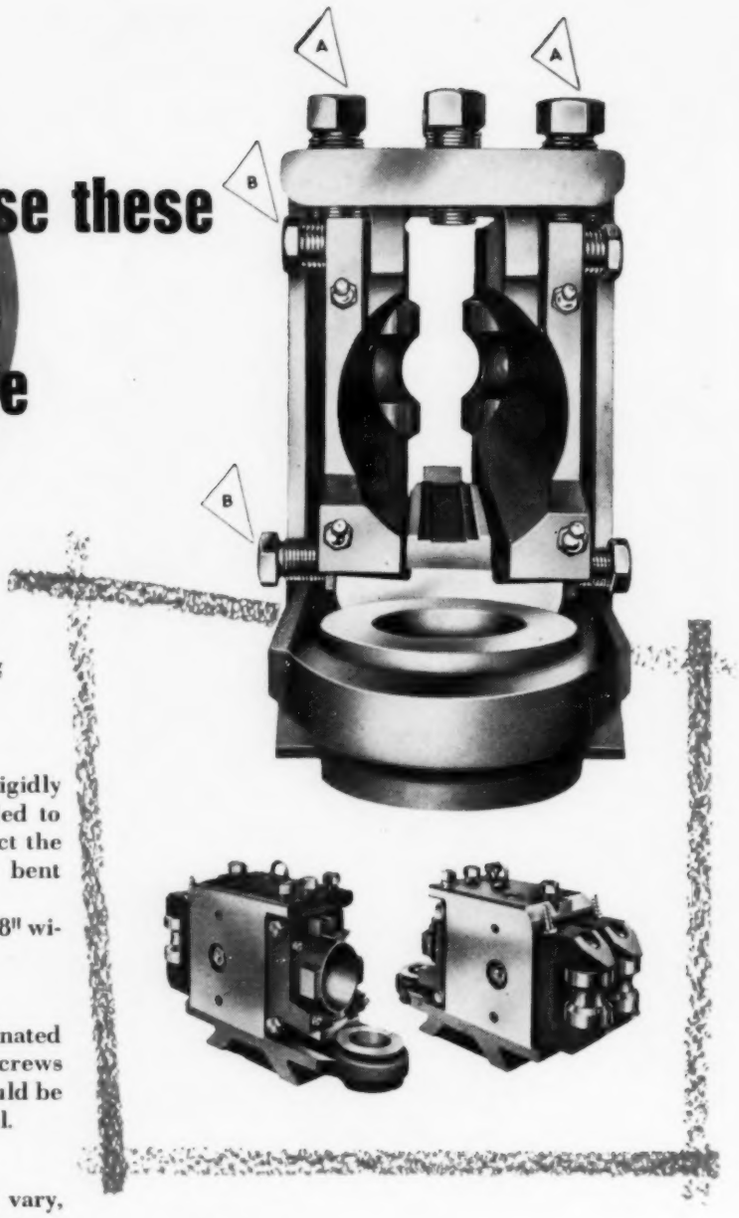
8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill



The Morgårdshammar Roller Guides — patented in most countries of industrial importance — are constructed according to the following principles:

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

2 The rollers are mounted on laminated springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted as shown by the arrows. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be plump, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.

7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and break-down oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mills. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

P.S. *Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.*

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Two 60-Ton Mill Type Bedford Cranes work independently or in tandem

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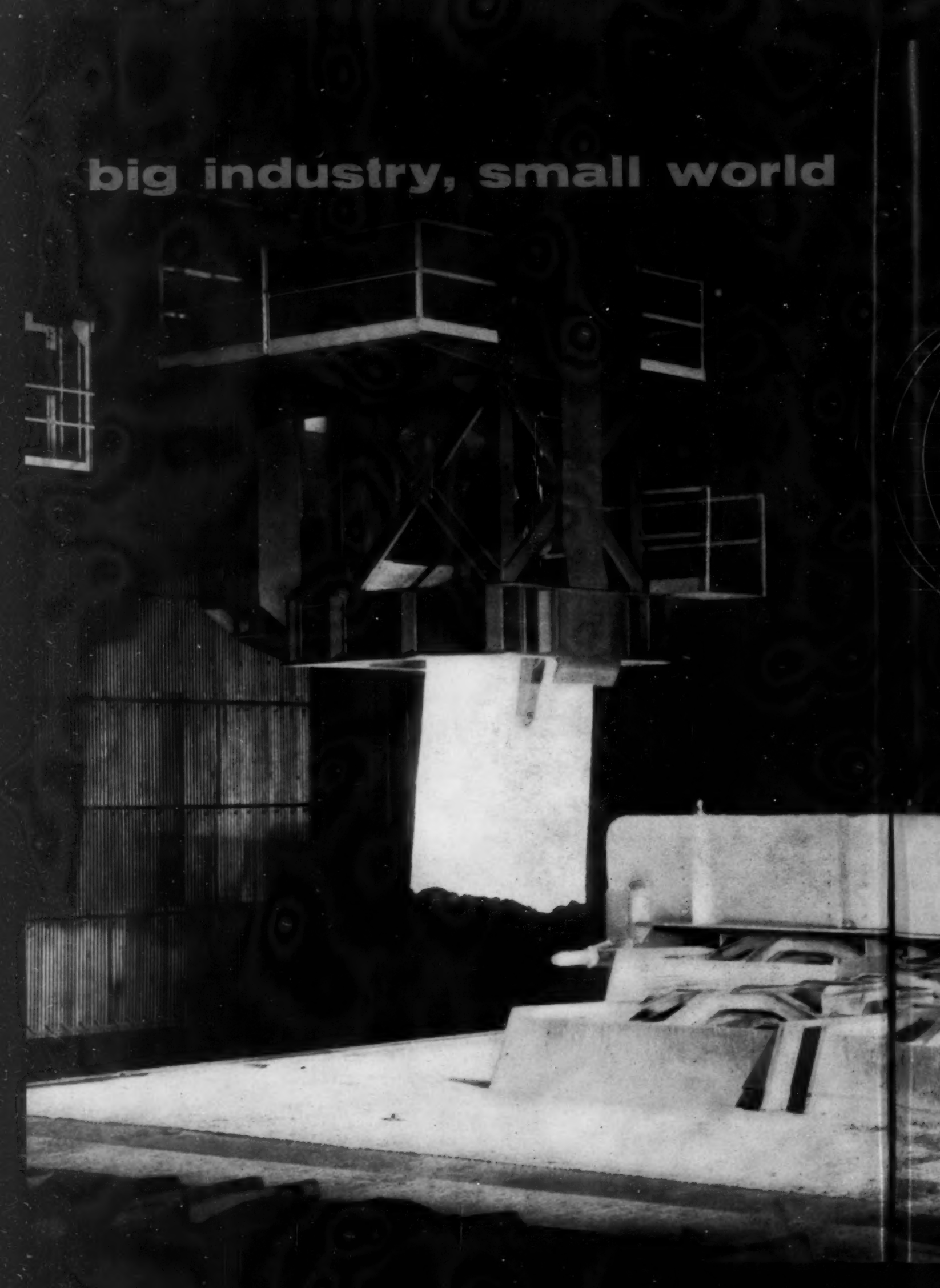
big industry, small world

annealing covers
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Wherever this steel goes—from first soak to final shipping dock—it will find that the big steel industry is a small world as far as 'Surface' equipment is concerned. Somewhere along the line, whatever its destined shape, the steel will be made more workable and more useful in 'Surface' furnaces.

Why is it so easy to bump into 'Surface' in steel mills? One reason is that 'Surface' has literally grown up with the steel industry. A better reason is the confidence that steelmakers have in the performance of furnaces and generators manufactured by Surface Combustion Corp., Toledo 1, Ohio.

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STEEL MILL FURNACES

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—with SELAS GRADIATION

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- Precise thermal control assures reproducible uniformity regardless of gauge variations.

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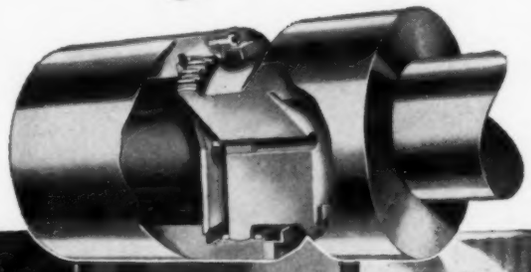

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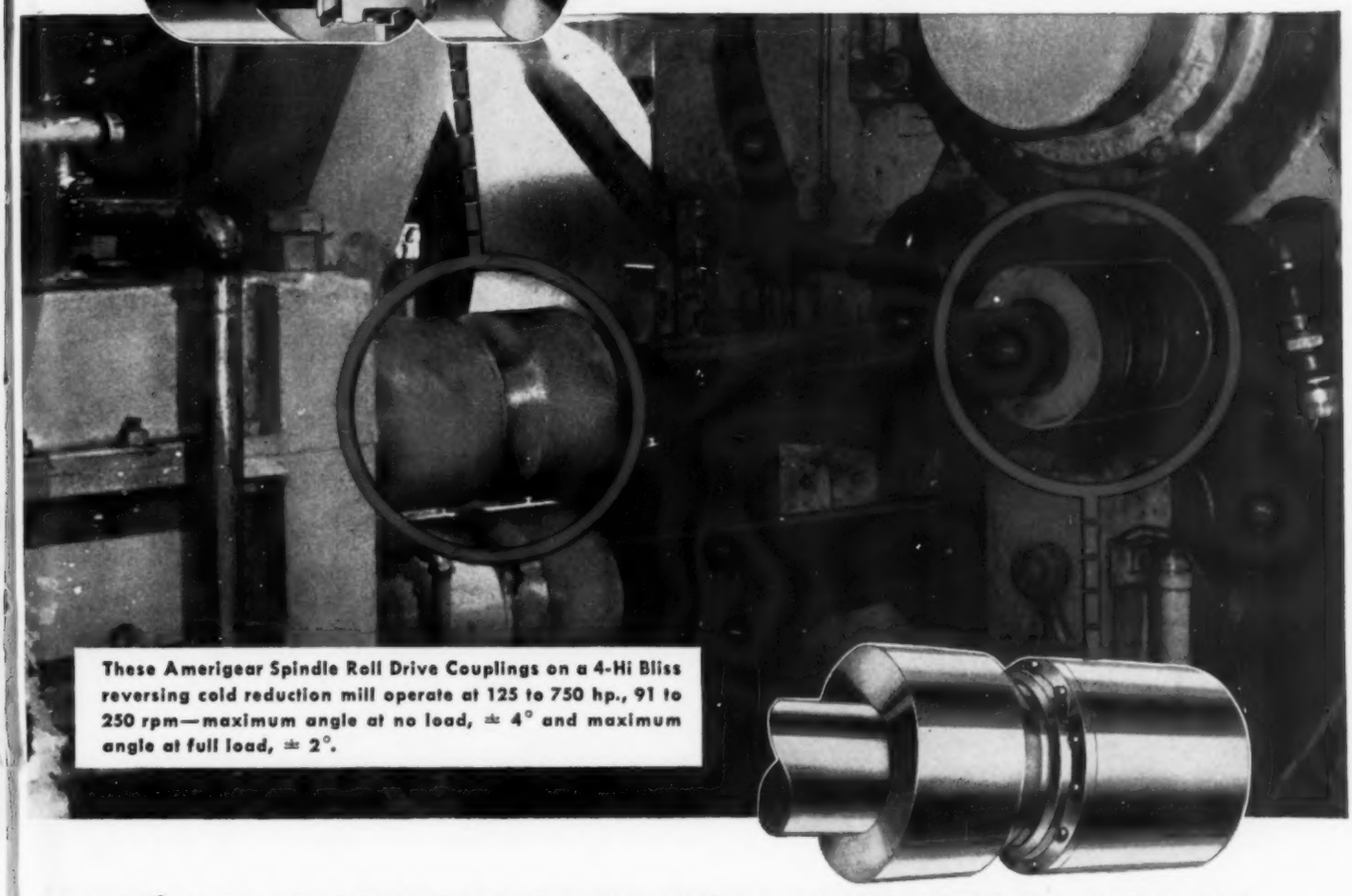

These Amerigear Spindle Roll Drive Couplings on a 4-Hi Bliss reversing cold reduction mill operate at 125 to 750 hp., 91 to 250 rpm—maximum angle at no load, ± 4° and maximum angle at full load, ± 2°.

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And By Accommodating For Roll Wear and varying distances between roll centers, Amerigear Spindle Roll Drive Couplings keep your maintenance expenses to a minimum. That's because they're precision-manufactured to transmit power to the rolls smoothly and continuously . . . even after repeated roll grinding . . . *without maintenance.*

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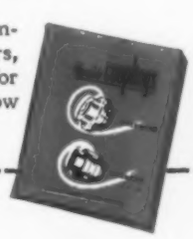

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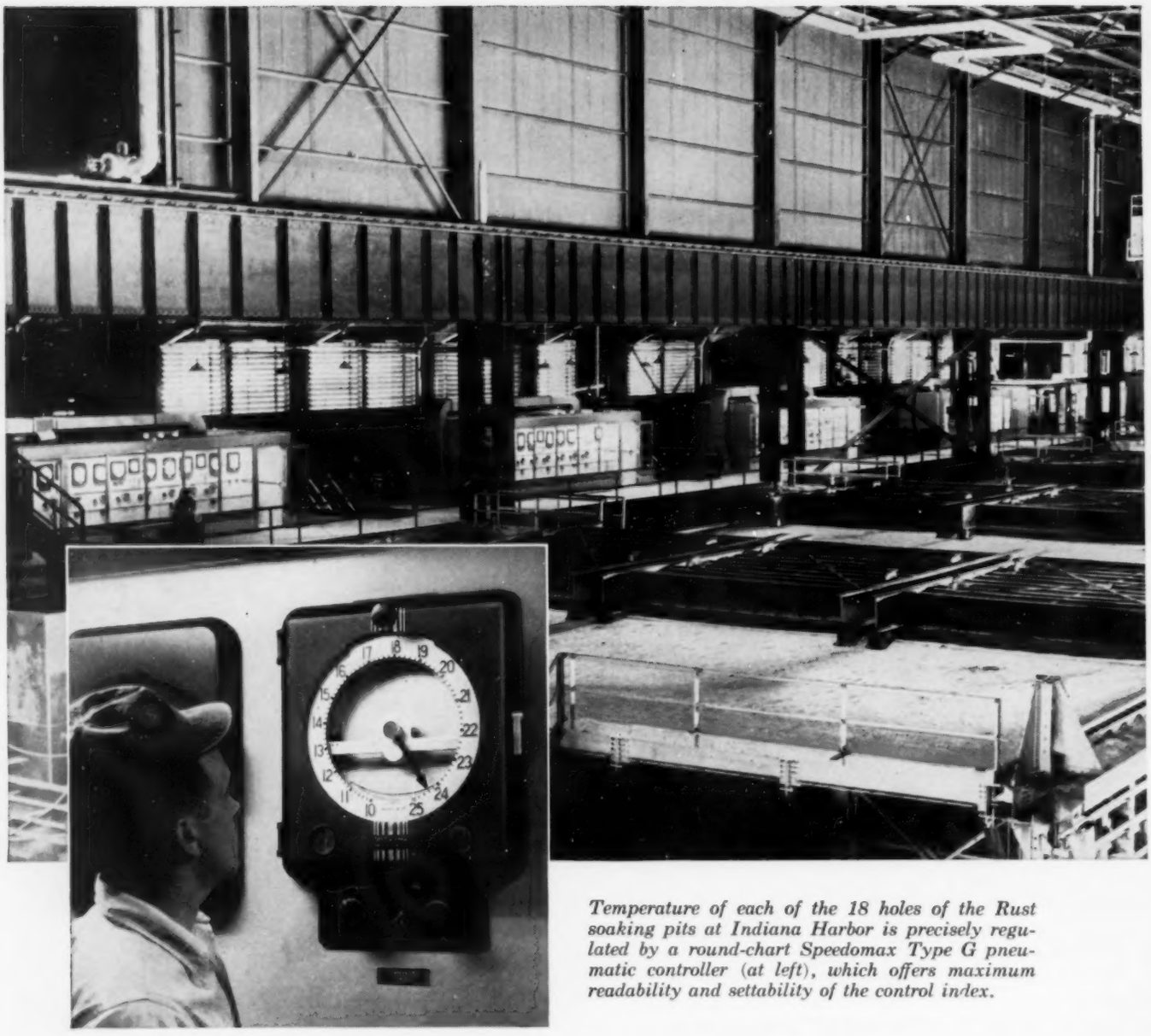

Temperature of each of the 18 holes of the Rust soaking pits at Indiana Harbor is precisely regulated by a round-chart Speedomax Type G pneumatic controller (at left), which offers maximum readability and settability of the control index.

At Indiana Harbor Works, too Youngstown Sheet & Tube installed Speedomax®

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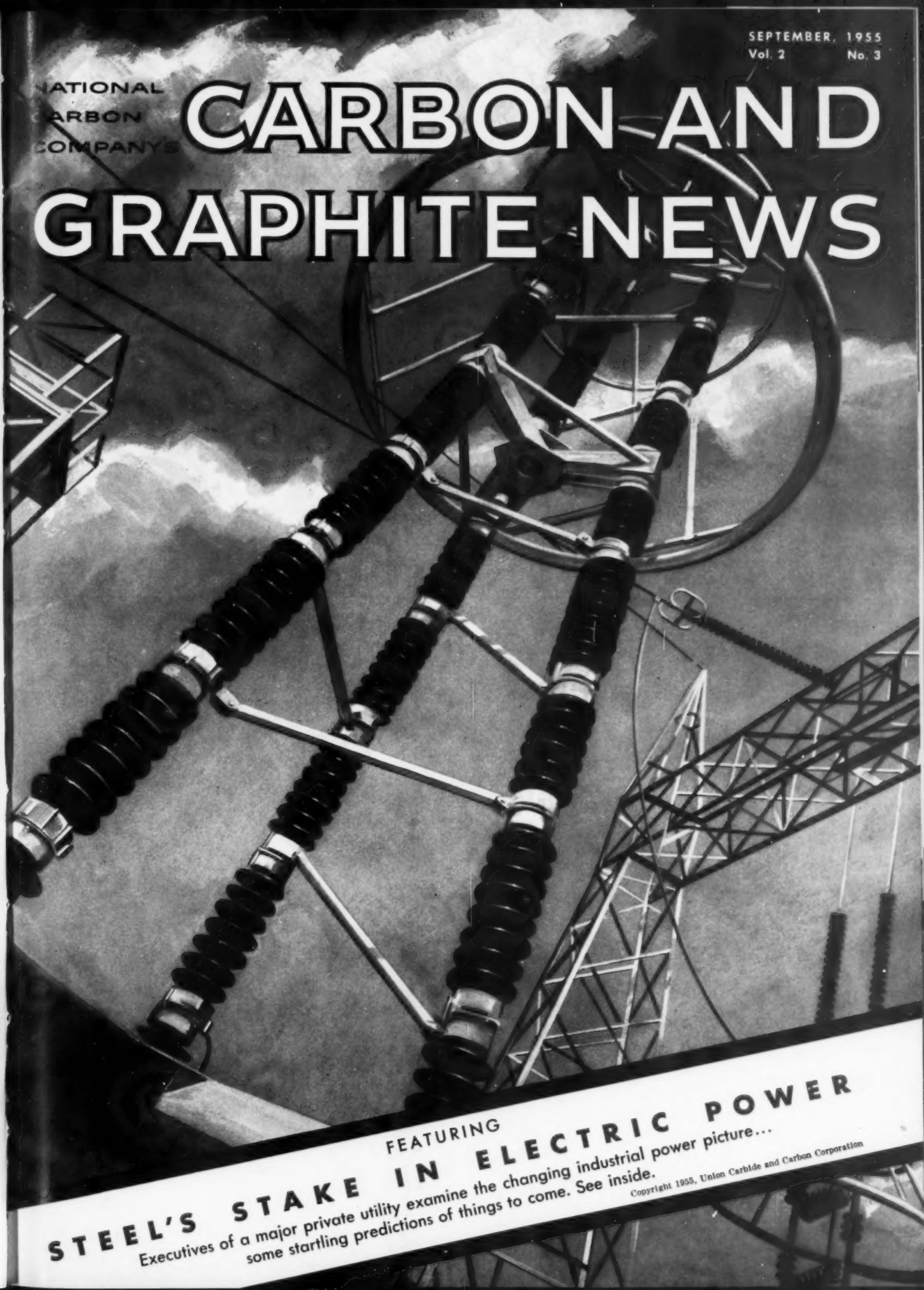

FEATURING

STEEL'S STAKE IN ELECTRIC POWER

Executives of a major private utility examine the changing industrial power picture... some startling predictions of things to come. See inside.

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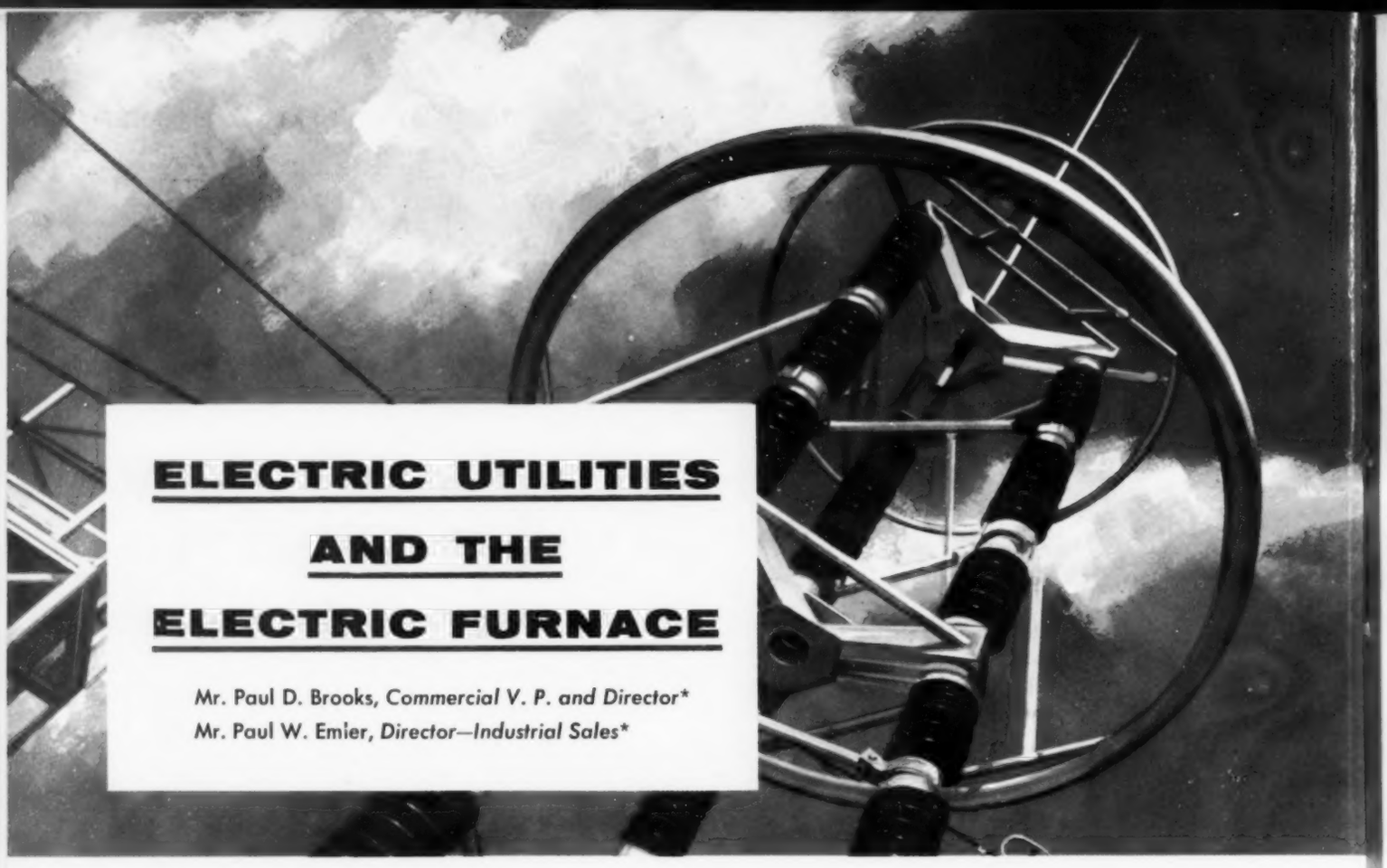


ELECTRIC UTILITIES AND THE ELECTRIC FURNACE

Mr. Paul D. Brooks, *Commercial V. P. and Director**
Mr. Paul W. Emier, *Director—Industrial Sales**

BEGINNINGS AND DEVELOPMENT OF ELECTRIC FURNACE USE

The use of the electric arc for metal melting extends back to the very beginning of the electrical era. It was recognized very early that the electric arc is a means of obtaining elevated temperatures and higher degrees of heat concentration than is possible through the combustion of fuels. Later, Sir William Siemens, using a dynamo of about 4 hp. capacity, applied the electric arc principle in melting platinum, iridium, steel and iron.

It was not until the end of the 19th century that any serious effort was made to use this melting process industrially. One reason for this unproductive interval was the absence of dependable electric power generating facilities great enough to meet demands for tonnage melting. In 1899, Dr. Paul Heroult began his extensive work on the production of steel from pig iron and later from common scrap iron. He also attacked the problem of refining steel and found that the electric furnace possessed features that permitted refining operations to be carried far beyond anything possible in the open-hearth furnace. The direct arc furnace, as we know it today, is a composite of the original Heroult furnace to which have been added numerous features, developed by other investigators, that time and experience have proved to be essential to the satisfactory and economical operation of the furnace.

The first electric arc melting furnace used in this country was installed in Syracuse in 1906. The original furnace was a 6 ton, 3 phase unit of 800 kw. capacity.

The crucible process for the production of special steels was gradually replaced by the electric arc melting process and, by 1918, 282 such furnaces, having an annual production capacity of 500,000 tons, were in operation. From that time until 1940, growth was moderate, capacity reaching 1.7 million tons. Beginning in 1940, electric furnace capacity increased at a rapid rate, reaching 4.6 million tons in 1943. Much of this expansion was due to the heavy demand for high-grade alloy steel and castings for the war effort.

With the end of the war, a large idle capacity of electric furnaces developed as production of electric steel dropped to 2.6 million tons. This availability of idle furnace equipment was one factor which induced experimentation in the use of the electric process for the production of plain carbon steel. It was found that, under a given set of conditions, the overall costs in electric furnace production of plain carbon steel might be as low as, or lower than, the overall costs of the open-hearth process. Older ideas about manufacturing costs of electric steel had to be revised, due to improved furnace design, larger transformer capacities, new process techniques and the fact that electric power cost had remained practically constant while the costs of most other commodities had increased. This experimentation led to an expansion of elec-

*American Gas and Electric Service Corporation

tric furnace capacity and to an increase in electric steel production from a post-war low of 2.6 million tons in 1946 to an all-time high of 7.3 million tons in 1953 (see Figure 1.)

One result of post-war interest in the electric arc furnace as a producer of low carbon steel was the study, "Comparative Economics of Open-Hearth and Electric Furnaces for Production of Low-Carbon Steel", prepared by Battelle Memorial Institute and sponsored by the Electric Furnace Survey Group. This group was comprised of a number of Electric Utility Companies, including an affiliated company of American Gas & Electric and Bituminous Coal Research, Inc. The study, which was based on plants having annual capacities of 250,000, 500,000 and 1,000,000 tons, concluded that for cold-charge practice, the electric furnace shop will have a lower overall production cost than the open-hearth shop and, for hot-metal charge, there will be little difference in overall operating costs between the two.

Operational advantages of the electric arc furnace have been well established and are recognized by all steel manufacturers. They include closer temperature control, closer metallurgical control, high heat efficiency, lower installation cost per unit of production, flexibility in operation to meet changing production schedules and flexibility in type of product.

The arc furnace, in addition to its place in ingot steel production, accounts for practically all the steel castings that are made in this country and it is rapidly gaining acceptance in the iron foundry. It is widely used with the cupola to duplex cupola iron and, by this operation, not only improves the quality of the iron but reduces the cost as well.

ELECTRIC POWER FOR ARC FURNACE OPERATION

Three important factors to be considered when selecting equipment to increase steel-making capacity are: the availability of an adequate electric power supply; the present cost of power; and what the relation between electric power cost and the cost of fuel for open-hearths is likely to be during the twenty or twenty-five year life of the equipment. Just as a lack of sufficient electric facilities delayed application of the arc furnace to industry in the 19th century, so now the availability of dependable electric capacity at reasonable and stable cost has hastened the recent growth of electric furnace capacity.

The remainder of this paper will discuss questions of electric power supply and power cost for electric arc furnaces. The discussion will generally represent the experience of the electric utility industry, but it will be based in part on our own American Gas & Electric experience and planning.

Electric arc furnace load is no stranger to the AGE System. Our experience in supplying this demand covers a span of more than thirty-five years. After serving a number of smaller furnaces, the first 100 ton arc furnace ever built was connected to our system at Canton, Ohio, in 1927. Since that time, electric arc furnace capacity served by the AGE System has grown to more than one-half million kva. In all cases, we have been able to work out in advance economical means to satisfactorily serve proposed arc furnace installations. We certainly feel that this type of load is a desirable one and, based on our past experience, look forward to serving many more arc furnace installations.

Before looking ahead at what future electric utility system capacities and electric power cost may be, let us look first at past electric load growth and power cost. Figure 2 shows the peak loads that have occurred on electric utility systems since 1930. Figure 3 shows the cost trend of electric power delivered to industry. It is apparent that during the time that electric demand quadrupled the unit cost of power delivered to industry was reduced 30%. Even during the years between 1940 and 1952, when commodity prices doubled, electric power costs remained stable, as shown by Figure 4.

The reasons for past reductions in power cost are important because the same factors will affect *future* costs. First, the electric industry is a dynamic industry. Reduction in cost of service naturally leads to expansion in use of service; and expansion in use of service makes possible still further reduction in power cost. Expansion in use of service is also affected by population growth, higher standards of living, the shorter work week and changing industrial technology. Table 1, which shows the relation of Employment, Productivity and the use of Electricity in Manufacturing Industries since 1920, clearly indicates one reason for this increase in electric power. Between 1920 and 1953, while the amount of labor per unit of production, expressed as million man-hours per FRB unit, was decreasing from 539 to 210, electric energy used per unit of production increased from 655 to 1,460 million kw-hr. At the same time, power used by industry increased from 1.21 to 6.94 kw-hr. per man-hour.

The two principal elements in the cost of electric power are the cost of generating the power and the cost of transmitting it to the user. Many technological improvements in generation and transmission have contributed to the axiom that the cost of power decreases as the demand for power grows. Among these advances are:

(Continued on next page)

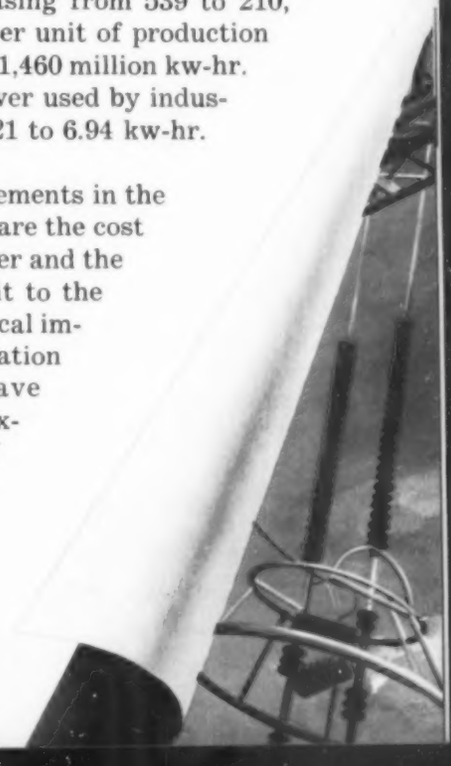


Table 1. Employment, Productivity and Use of Electricity in Manufacturing Industries

YEAR	FRB INDEX OF MFRS.	MILLION kw-hr. PER FRB INDEX	MILLION MAN-HRS. PER FRB INDEX	kw-hr. PER MAN HOUR
1920	39	655	539	1.21
'25	48	798	383	2.08
'30	48	1076	336	3.21
'35	46	1206	301	4.01
1940	66	1197	259	4.62
'45	110	1107	259	4.28
'50	113	1454	224	6.48
'53	136	1460	210	6.94

Source: Federal Reserve Bulletin · Handbook of Labor Statistics
Monthly Labor Review · Historical Statistics of the U. S.
Federal Power Commission · U. S. Census of Manufacturers

Figure 1. Annual Production of Electric Furnace Steel in the United States

Source: American Iron and Steel Institute

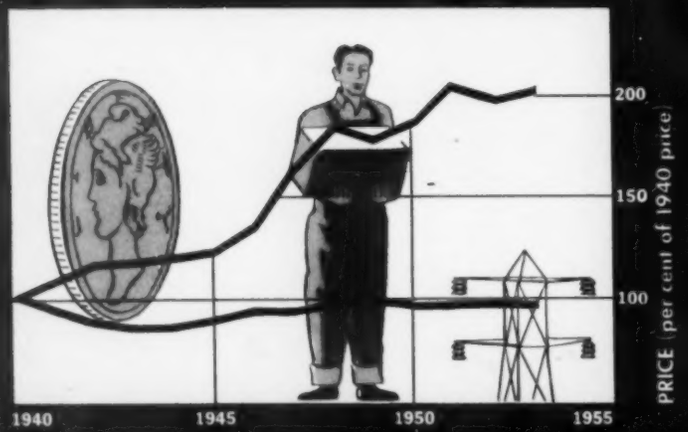
adoption of the reheat cycle, higher steam temperatures and pressures, single reheat boiler-turbine units, centralized generating-plant controls, simplified power-plant design and layout, and larger-sized generating units. A direct result of these improvements was the increase in generating-plant fuel-efficiency as shown by Figure 5.

This relation between electric load growth and power cost is one of the principal keys to future power costs. Let us look now at the peak loads which are expected for future years, shown by Figure 6. The 1975 load on electric utility systems is expected to be between triple and quadruple the 1953 load. We do not know precisely what new loads and increases in existing loads will occur to bring about this large increase in power requirements. We can foresee, however, and are planning for, tremendous advances requiring very large amounts of power in the steel and metal industries, the chemical industry, in electric space heating and air conditioning and other uses. These uses, combined with the effects of population growth and improved living standards, are expected to bring the peak loads indicated.

Assuming a stable economy and the load increases predicted, cost of electric power is likely to continue to decline. The major portion of electric power generated in this country is from steam generation using coal as a fuel, and this situation is likely to continue for another twenty years. Future coal prices are, therefore, important in estimating future power costs, just as future prices of gas and oil are important factors in open-hearth furnace costs. Although variables, such as technological changes, governmental controls and basic supplies, make predictions difficult, the Battelle study did devote considerable attention to the subject. Figure 7 is from that study and indicates that, while coal prices are likely to remain stable or decrease in the future, oil and gas prices will probably increase. Many other factors will contribute to the probable decline in power costs, but two developments pioneered by AGE are indicative of what will be accomplished:

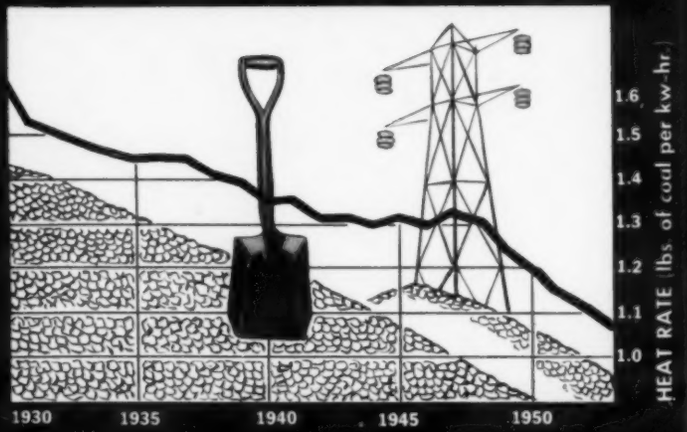
The first of these is the development of Super-Critical Pressure steam generation. The 4,500 psi, 1,150 Degree F, double-reheat-steam, power generating unit, which is now under construction at

Figure 4. Price of Electric Power sold to Industry compared to Price of all other Commodities*



*Except Farm Products and Food
Source: Edison Electric Institute, Bureau of Labor Statistics

Figure 5. Average Fuel Burning Efficiency of all Utility Steam Plants

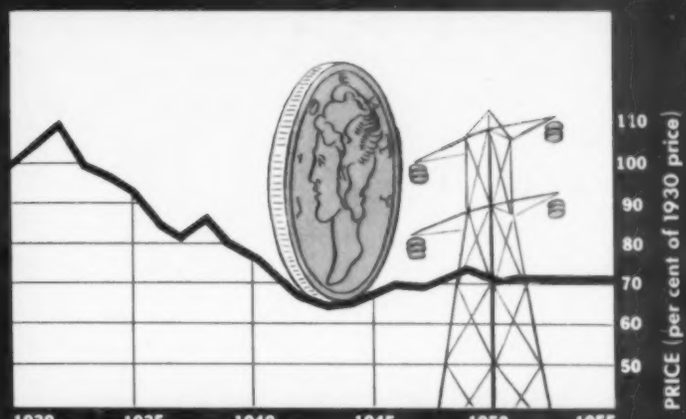


Source: Federal Power Commission

Figure 2. Peak Loads—Total Electric Utility Industry

Source: Edison Electric Institute

Figure 3. Price of Electric Power sold to Industrial Customers—Total Electric Utility Industry



Source: Edison Electric Institute

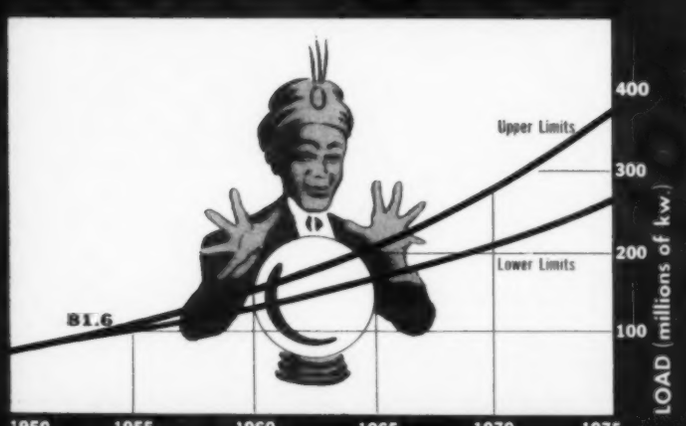
Philo, Ohio, will be the world's most efficient unit with an expected heat rate of 8,500 B.t.u. per kw-hr. The average of all steam plants operating in this country was 13,366 B.t.u. per kw-hr. in 1952. The large increase in power requirements in the future will mean that almost all generating equipment will be modern by today's standards; and, even assuming no further progress beyond the Philo unit, fuel used per kw-hr. in 1975 will be only about two-thirds of what it is now.

A second development pioneered by AGE is the use of 330-kv. transmission lines to handle today's loads and those of the future. One 330-kv. circuit will transmit about six times as much power as one 132-kv. circuit at a cost of only about twice that of the 132-kv. circuit. As loads grow, making higher voltage transmission practical, transmission costs per unit of power will decrease.

In addition to the above factors, which will tend to decrease power cost, there is Atomic Power. Undoubtedly, it will have its place in future power generation; but it is unlikely that anyone knows whether the time in which Atomic Power can be brought to fruition as a large-scale economic operation is of the order of five years or whether a much longer period will be required. We are now actively engaged in the research and development stage of the art of Atomic Power generation.

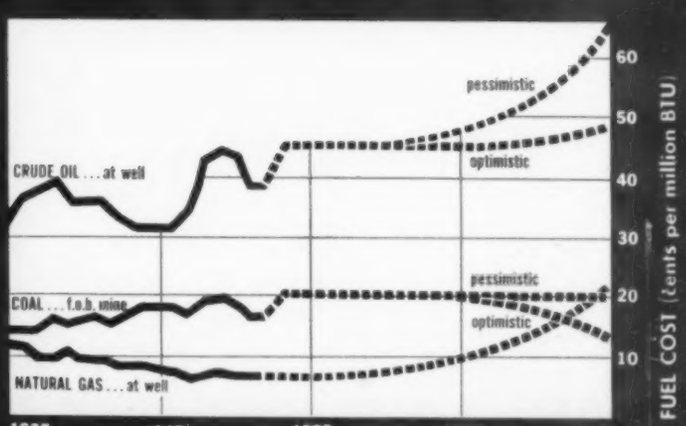
Based on all known factors, AGE is confident that power loads and power systems will grow tremendously in the future and that power costs are likely to continue decreasing. Electric power, which is industry's biggest bargain today, will be in an even better competitive position with the fuels of tomorrow. There will be adequate electric capacity to supply all of the needs of the country, including not only electric arc furnaces for the steel, metal and ferro-alloy industries but electric arc furnaces for calcium carbide plants, phosphorous plants and many others. The growth in electric system capacity will tend to solve many of the electric arc furnace supply problems which have been present in the past. Low cost electric power of adequate capacity, combined with the inherent advantages of the electric arc furnace and the improvements being made in furnace equipment and techniques, will all contribute to a continuing expansion of electric arc furnace applications.

Figure 6. Future Load Forecast—Total Electric Utility Industry



Source: Electric Power Survey Committee, Edison Electric Institute

Figure 7. Past, Present and Potential Trends in U. S. Price Levels of Primary Mineral Fuels



Source: Electric Furnace Survey Group Study, "Comparative Economics of Open-Hearth and Electric Furnaces for Production of Low-carbon Steel."

NATIONAL CARBON AS A CUPOLA REFRACTORY

"The foundry industry today is in a period of transition. There are about 5,000 cupolas in the U.S. producing grey cast iron . . . and it's possible that no two foundries have precisely the same conditions or requirements. So don't expect a revolution overnight . . ."

This quotation from a veteran in the grey iron foundry field illustrates two important aspects of that industry today. One is an awareness of tradition. The other, a susceptibility to change. Together they comprise a basic philosophy of "Make Haste Slowly"—a hard one to beat when making policy for a period of sound, competitive growth.

Among the most interesting of the new practices to receive industry-wide attention is the use of carbon — in the form of blocks, brick shapes and paste — as a cupola refractory. Undoubtedly, the trend toward carbon refractories in the grey iron industry received impetus from its success in hearths, side-walls and even up to the mantles of blast furnaces — nearly 40% of which are now lined with carbon in some form.

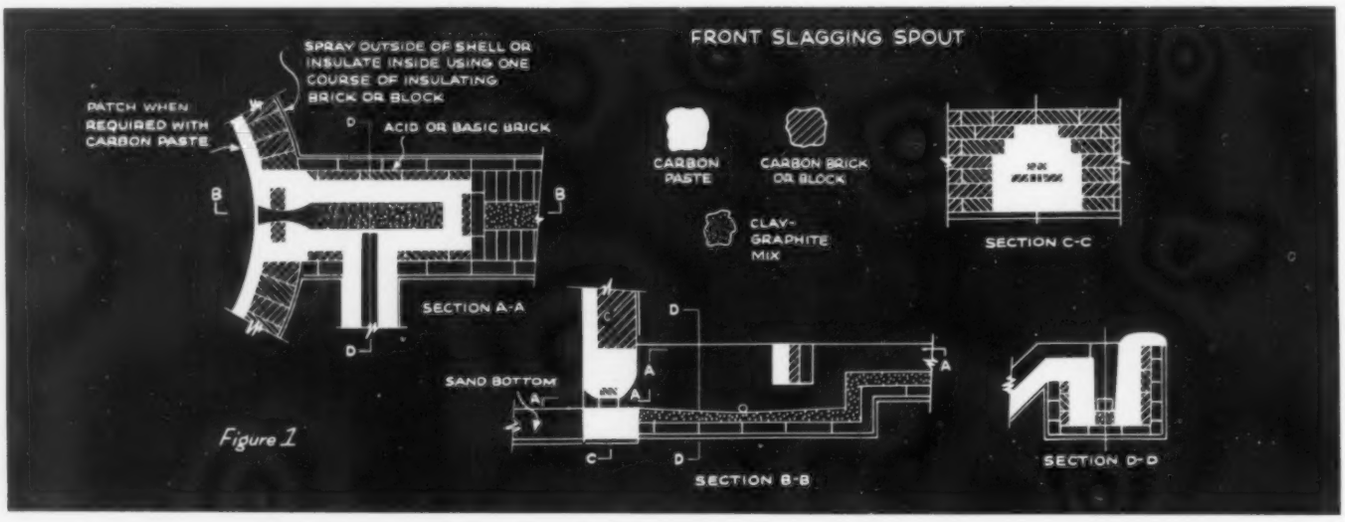


Figure 1

PROPERTIES OF CARBON AS A CUPOLA REFRACTORY

Carbon is:

Completely inert to the chemical effects of slag corrosion, either acid or basic

Highly resistant to thermal-shock and dimensionally stable

Not wet by molten metals or slags

High in abrasion resistance at elevated temperatures

Low in absorption into the molten bath

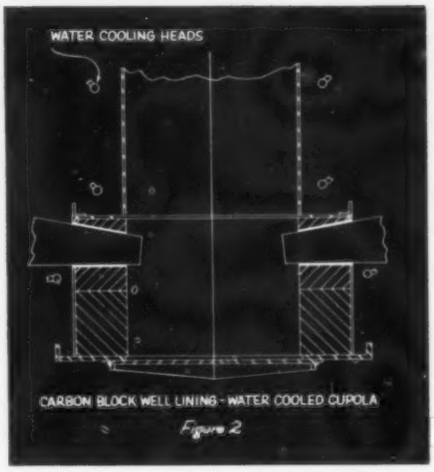
Available in all the forms in which other refractory materials are provided.

If these properties are considered in terms of the advantages each one offers the cupola operator, the value of carbon as a refractory is clearly evident. For example, its chemical inertness completely eliminates slag corrosion—undoubtedly the greatest single cause of damage to acid or basic linings. Breakage and joint failure due to shrinkage cease to be problems because of carbon's low coefficient of expansion. Clean-out of metal and slag is greatly accelerated by carbon's low adhesion to these materials. Since it has no melting point, carbon retains its favorable resistance to abrasion at all operating temperatures. Its low absorption into the bath rules out loss of refractory by this means. And, finally, because it is available in blocks, brick, shapes, paste and cement of various formulations, carbon requires no substantial change in conventional lining and maintenance practices.

APPLICATIONS

The merits of carbon for lining the front slagging trough or spout of the cupola are generally recognized. Troughs with carbon linings are giving economical, trouble-free service in both acid and basic cupolas. A typical trough lined with carbon brick and carbon ramming paste is illustrated in Figure 1. In carbon-lined troughs, such wear as occurs is due almost entirely to simple erosion and can readily be repaired with carbon paste which is baked in by the normal heat of operation.

In the cupola proper, carbon has found its most wide-spread use to date in the well zone. Carbon



well-linings have given very satisfactory service in both acid and basic cupolas, although the preponderance of installations so far is in the field of basic slag practice where the refractory first-cost differential is relatively small. Generally, it may be said that wherever it is desirable to operate a cupola, either acid or basic, for long periods, or where refractory costs are averaged out against large annual tonnages, carbon well-linings look good from any angle—including cost-per-ton of metal poured.

Figure 2 illustrates a type of cupola design wherein carbon lining of the well is virtually dictated by all considerations of economy and efficiency of operation. Here oxidation in the melt-zone is not a problem because external water cooling of the steel shell has eliminated refractories entirely from this area. The carbon-lined well may be expected to give from 6 months to 1½ years or more of service with only routine maintenance, and performance of the carbon refractory blocks is such that the bottom need be dropped only at very infrequent intervals.

This design, when it employs carbon in the well, offers a unique flexibility of operation in that slags may be varied from acid to basic to "neutral" as required to meet changing product specifications. This feature is especially interesting at a time when more and more foundries are being required to produce a greater variety of irons on short notice and under highly competitive conditions. Basic practice also substantially reduces sulphur content — an advantage which finds its chief application in low-sulphur base for the ultimate production of nodular or ductile iron.

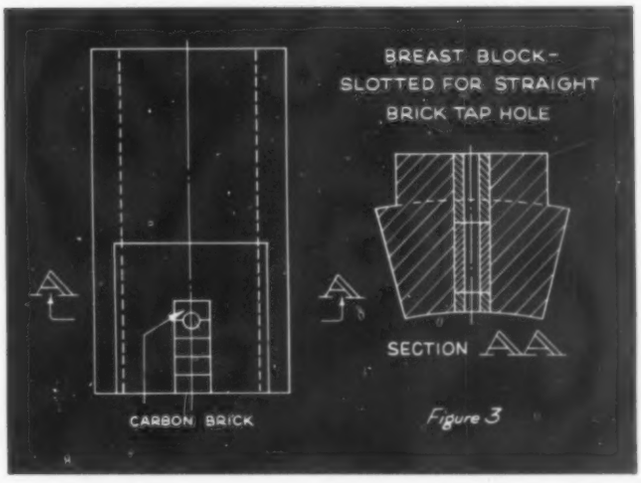
In addition to its use in trough and well, carbon has been very successful in breast and tap-hole construction. Several methods of application have been employed, with results indicating preference for a monolithic breast block of carbon, grooved to accommodate carbon and ceramic tap-hole brick (figure 3). The block is placed in the breast and the breast opening is closed with suitable ramming materials.

As regards melt-zone applications of carbon, experiments are now under way to develop a type of construction which will perform to economic advantage in this highly oxidizing atmosphere.

BLOCK, BRICK OR RAMMING PASTE?

Determination of the form in which carbon is used in the cupola should be made largely on the basis of economics.

For length of life, ease of maintenance and speed of installation, carbon block of the maximum size which can be handled by plant facilities are strongly recommended. Cost is about 2-2½ times that of carbon brick, but when averaged over the large tonnages of continuous or heavy, intermittent operation of the unit during the long life of the refractory, this consideration becomes negligible.



Carbon bricks, while physically the same material as the larger shapes, require longer to lay up and have a greater number of exposed joints. However, where production is intermittent, and carbon is being considered as a direct replacement for other types of refractory bricks, their lower first cost may determine their choice over block.

Carbon paste is used for maintenance of both pre-baked carbon brick and blocks and is handled much like any other plastic refractory patching material. Its cost — much lower than pre-baked carbon — has led to its use as a ramming-mix liner for the entire cupola well. While life is relatively short, such jobs compare favorably on all counts with refractory linings other than carbon. Frequently, carbon paste has supplanted other types of plastic patching materials with excellent results,

(Concluded on next page)

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Write National Carbon Company, 30 East 42nd Street, New York 17, New York, giving name, title and company address.
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even in wells and troughs lined with magnesite or fire clay brick.

CONCLUSION

With many carbon-lined cupolas now in operation and many more projected for the immediate future, carbon definitely occupies a place in the cupola refractory scene. Moreover, the progressive trend exemplified by the type of operation in which carbon is now being used, together with the sometimes astonishing degrees of efficiency and economy reported over former linings, bears an importance out of all proportion to the number of cupolas as yet involved.

ADVANTAGES OF CARBON FOR CUPOLA LININGS

- Eliminates refractory damage by slag corrosion
- May be used with acid, basic or neutral slags without relining.
- Will not crack or spall from thermal shock
- May be quenched when hot, speeding cupola repairs
- Retains mechanical strength at high temperatures
- Does not adhere to metal or slags
- Cannot soften or melt
- Provides long, trouble-free life for extended periods of operation

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UNION CARBIDE'S NEW LAB TO SEEK MATERIALS OF TOMORROW

Union Carbide and Carbon Corporation is building a new Research Laboratory at Parma, Ohio, to be managed by National Carbon Company, a Division of the Corporation.

While other major UCC research units are devoted primarily to inorganic chemistry, organic chemistry, plastics and metallurgy, the work at Parma will be in the fields of physics and the interrelation of physics and chemistry. This is an appropriate assignment for National Carbon since its present research organization is well fitted to function in these fields.

The new Research Laboratory will engage in basic, exploratory work. Much of it will be on solid state physics research in the broad abstract sense, as well as the practical investigation and design of materials for future industrial requirements. Work will be done with metallic and non-metallic compounds of carbon, as well as analogous compounds, such as inter-metallics and semi-conductors. Activities will be directed toward specific end-products only to the extent that such products have their primary origins in the discovery of new and fundamental material-process applications. On this broad basis, the horizons of this new research operation are virtually unlimited and, consequently, unpredictable.

Among the possible far-future developments to come from studies at the new UCC Research Laboratory are materials for new and improved transistors and related electronic devices that can play a tremendously significant role in an expanding electronic world.

The key to further development of new ferrites may be found. Ferrites are complex, inorganic compounds having high permeability at low flux — they could have wide application in electronic computers and automation devices.

New refractory compounds, as well as improvements in the established materials, such as graphite, could come out of research on totally new materials and processes for this important industrial application.

Photo-sensitive materials, leading to new and more efficient methods of converting light energy to electrical energy, might be developed.

National Carbon Company's present products, such as electrodes, brushes, projector carbons, dry batteries and carbon and graphite shapes, have resulted from the application of traditional physics and the sciences of optics, electrophysical chemistry, conductivity, and surface phenomena. Research along these lines will, of course, be continued and amplified; but in this new laboratory, emphasis will be placed on the more radical approaches which the new physics may suggest.

The Laboratory will cost several million dollars, with ground improvements, buildings, equipment and furnishings, and will accommodate a staff of approximately 200 research personnel, plus clerical and service personnel.

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
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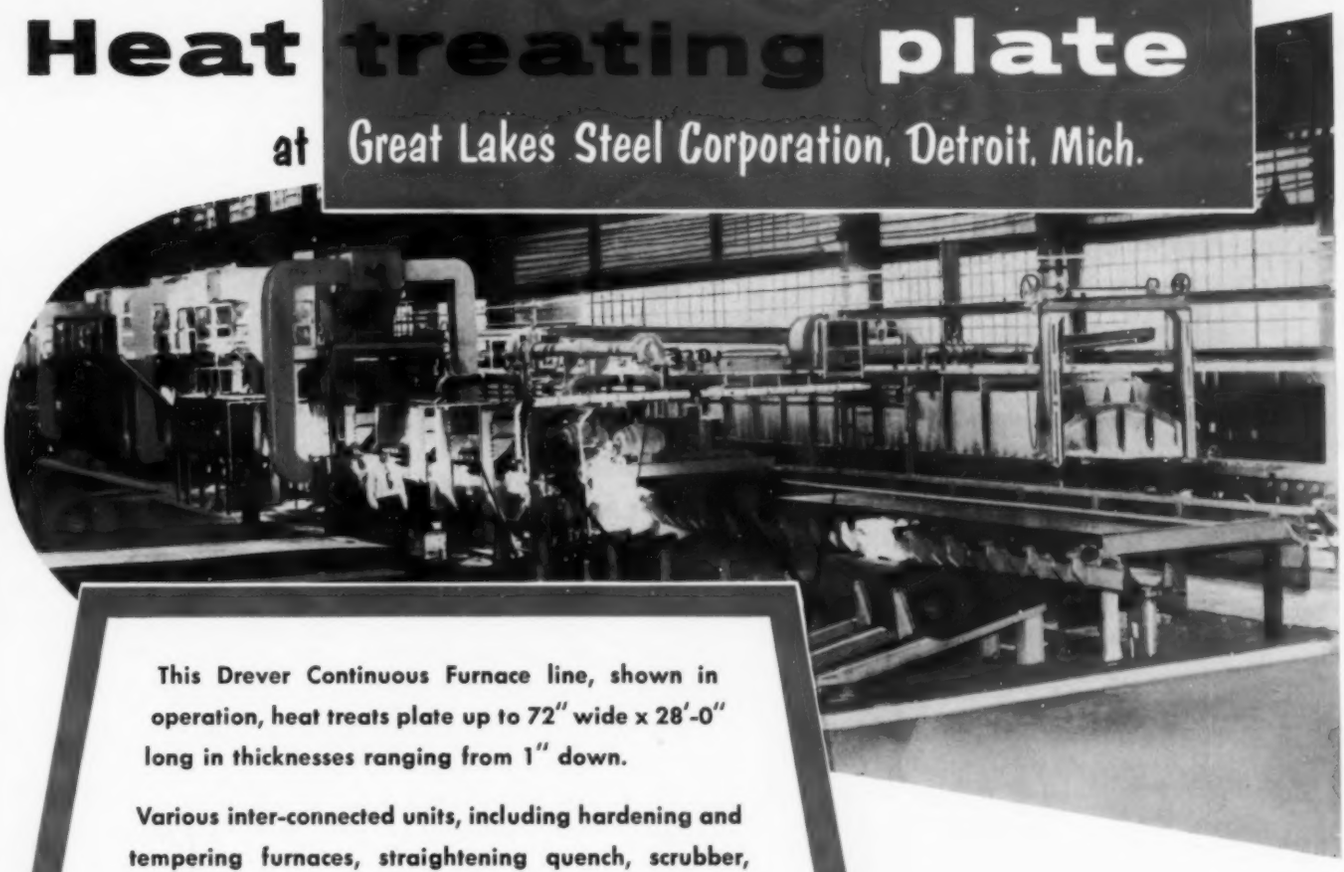
In Canada: Union Carbide Canada Limited, Toronto

LITHO IN U.S.A.

Heat treating plate

at Great Lakes Steel Corporation, Detroit, Mich.

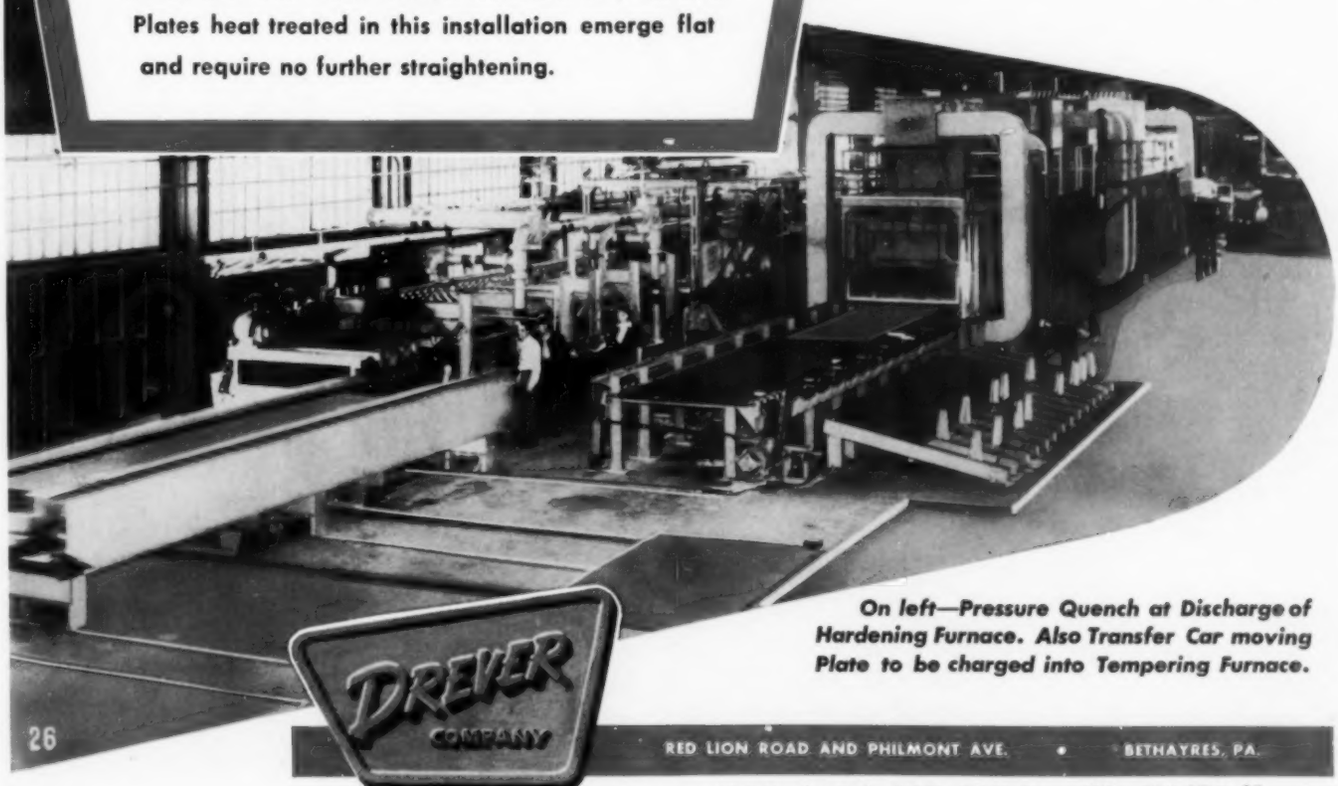


This Drever Continuous Furnace line, shown in operation, heat treats plate up to 72" wide x 28'-0" long in thicknesses ranging from 1" down.

Various inter-connected units, including hardening and tempering furnaces, straightening quench, scrubber, kick-off tables and transfer car are operated from centrally located pulpits.

Drever's reputation is based on performance of units such as this, where quality of product, high production rates, and low maintenance costs are key factors. Plates heat treated in this installation emerge flat and require no further straightening.

Production is High and Costs are Low



On left—Pressure Quench at Discharge of Hardening Furnace. Also Transfer Car moving Plate to be charged into Tempering Furnace.

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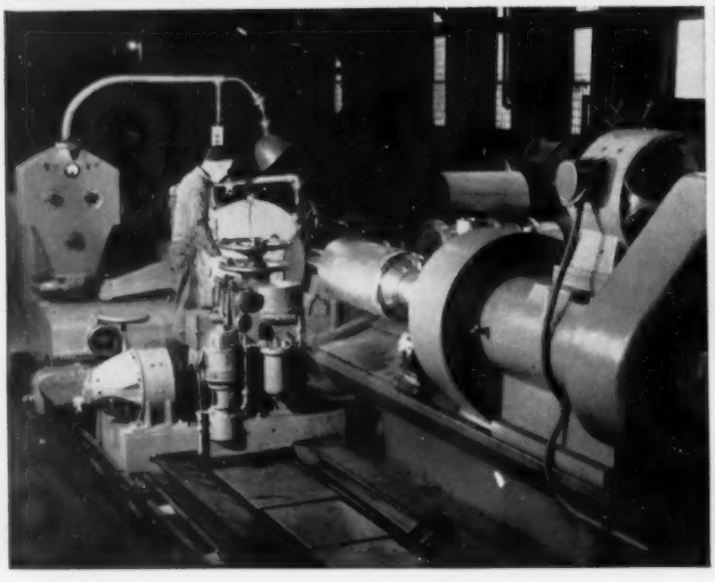


Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period April 26, 1955 through May 10, 1955 . . . .

CONTROLLING COATING THICKNESS IN CONTINUOUS GALVANIZING

▲ U.S. 2,708,171, issued May 10, 1955 to Charles L. Inglefield, Jr. and assigned to United States Steel Corp., describes a method of controlling the coating thickness at the strip edges in continuous strip galvanizing.

As shown in Figures 1 and 2, galvanizing lines include a galvanizing pot 10 which contains a bath of molten zinc at 800 to 875 F. A continuous steel strip S is led into the pot, passes around a sink roll 12 at the lower portion of the pot, and emerges between a pair of grooved coating rolls 14, 15 at the bath surface. At high speeds the coating rolls tend to draw out the coating near the strip edges so that the coating attains a greater thickness at the edges than in the central portion of the strip. This tendency produces undesirable variations in the final strip and its corrosion characteristics. In order to avoid this, it is necessary to operate at speeds no greater than about 100 fpm.

In the present invention, increased speeds are made possible by mechanically blowing molten zinc from the edges by means of gas jet flames. As shown in the Figures, gas burners 17 equipped with control valves 17a, are directed down against the strip edges just above the coating rolls. These burners are positioned so that the gas jets impinge on both faces of the strip at the edges. The flow of gas actually impinges on the coating before combustion takes place. Therefore, the gas velocity has the mechanical effect of blowing excess molten zinc down off the strip surface. The flames are regulated not to heat the surface of the strip at the edges appreciably above the temperature at which they emerge from the coating rolls, but merely to maintain them at this temperature longer than the remainder of the strip. The resultant heating of the edges prevents formation of a cobweb structure while maintaining a spangled appearance in the finished product.

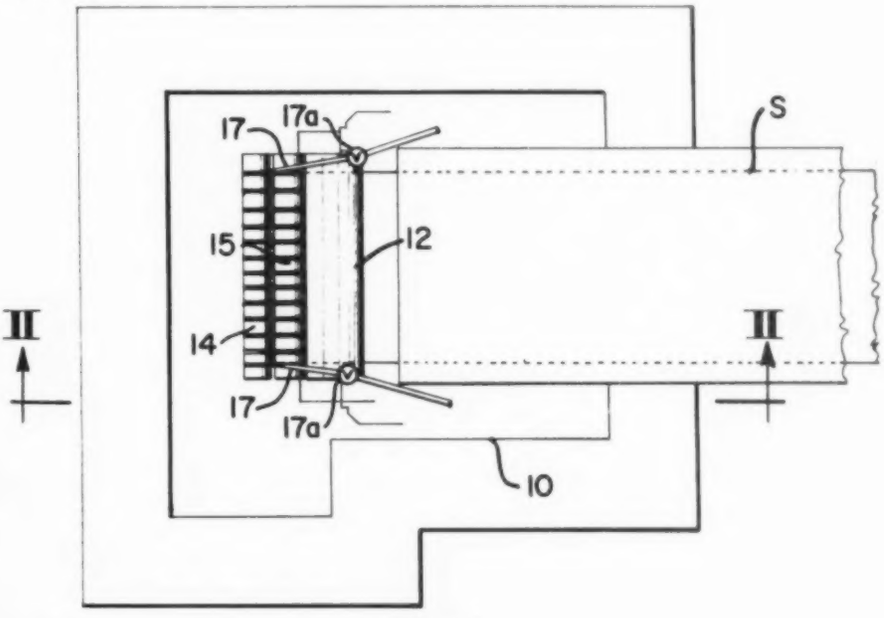


Figure 1

HOT METAL MIXER WITH MOVABLE COVER

U.S. 2,708,108, issued May 10, 1955 to Harry L. McFeaters and assigned to Pennsylvania Engineering Corp., describes a hot metal mixer with a cover which can be lifted and moved, in order to expose the interior of the mixer. The object is to make it possible to cool the interior of the mixer

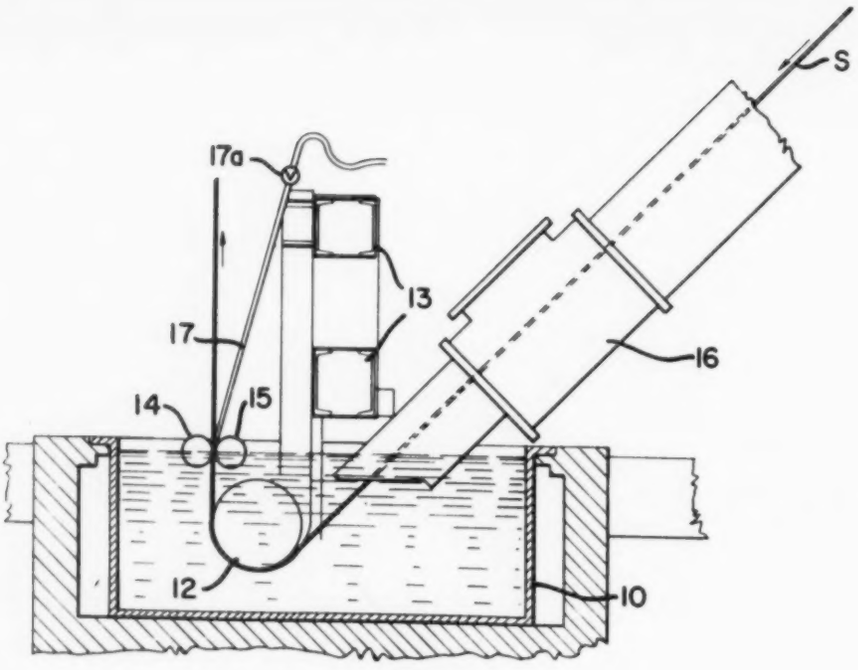


Figure 2

rapidly when it is empty, so that workmen can enter and make repairs.

TINCTURE OF IODINE AS ACID PICKLING INHIBITOR

In the acid pickling of ferrous metals it is economically advisable to add inhibitors to the pickling baths in order to retard the acid attack on the base metal without appreciably affecting the rate of attack against the rust or oxide film which is to be removed.

In U.S. 2,708,184, issued May 10, 1955 to Karl F. Hager and Morris Rosenthal, and assigned to the Secretary of the Army, it is disclosed that tincture of iodine is an effective pickling inhibitor. Such tinctures generally contain about 2 per cent of iodine dissolved in ethanol.

It is known that ethanol normally increases the rate of attack of pickling acids against the base metal. It is also known that iodine alone has some inhibiting effect. It is now found that ethanol and iodine exert a synergistic effect on each other, so that the tincture of iodine is more effective than either alone as an inhibitor, and the attack on the base metal is completely overcome.

The patent gives data showing this effect.

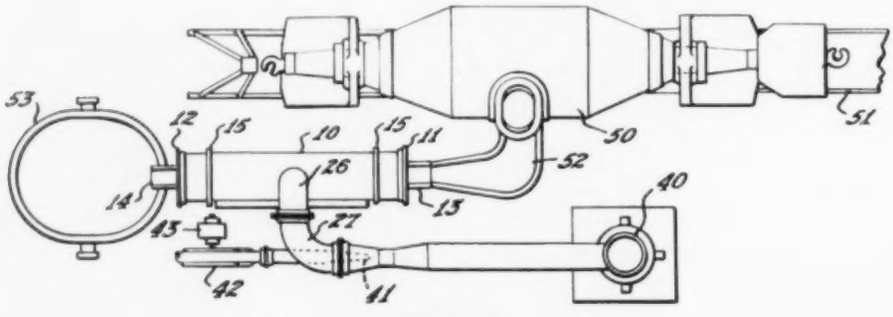


Figure 3

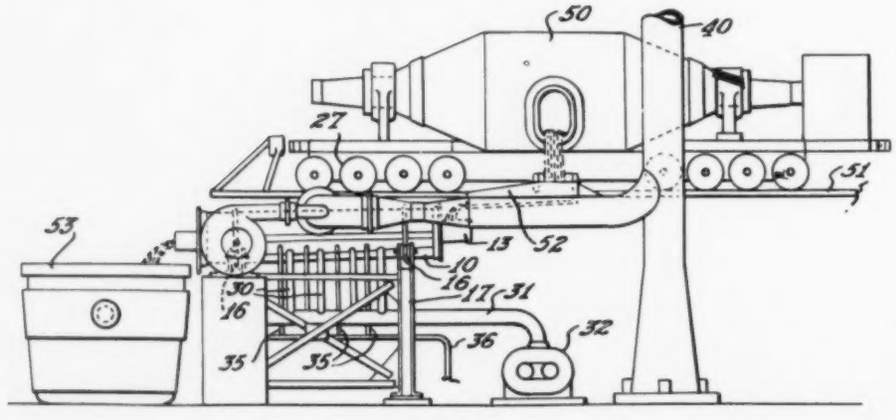


Figure 4

APPARATUS FOR CONTINUOUS BLOWING OF PIG IRON WITH OXYGEN

U.S. 2,708,572, issued May 17, 1955 to Edwin B. Hudson and Charles R. Taylor, assigned to Armco Steel Corp., describes apparatus for the continuous blowing of pig iron with oxygen, to reduce the silicon and manganese content of the metal preparatory to charging to an open hearth furnace.

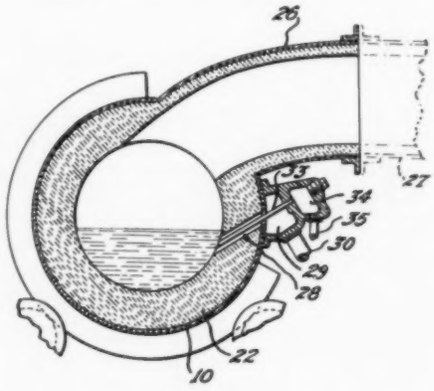


Figure 5

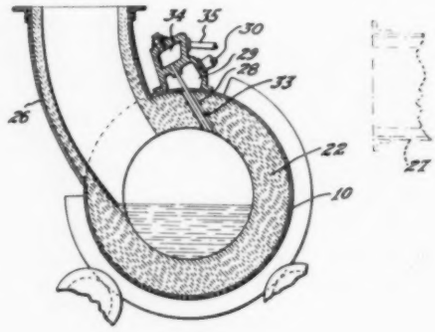


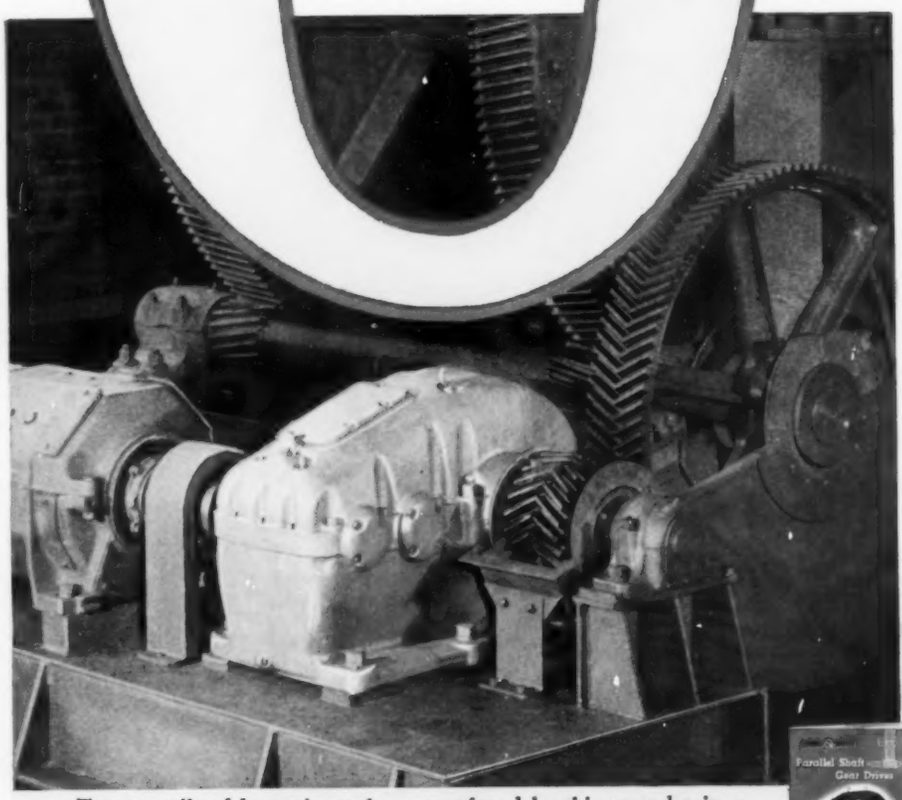
Figure 6

In Figures 3 and 4 (the former being a top view and the latter a side view), the blowing apparatus proper is indicated at 10. The blowing vessel may be rotated by means of rings 15 from its blowing position to a drain-

6 reasons why

Link-Belt Parallel Shaft Gear Drives

ASSURE CONTINUOUS PRODUCTION



Ten-ton coils of hot strip steel are transferred by this up-ender in a modern mill. Link-Belt parallel shaft gear drive fitted with outboard bearing on output shaft withstands the exceptionally tough duty.

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5. TO PREVENT REVERSE ROTATION on conveyors, elevators and similar equipment, a built-in backstop can be provided.
6. FOR EASY INSPECTION OR MAINTENANCE, all parts can be removed without disturbing base, which can be grouted in concrete.

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13,874

ing position (Figures 5 and 6, respectively). The blowing vessel 10, as well as the charging spout 13 and the discharge spout 14, are lined with refractory material 22, as shown in Figure 7.

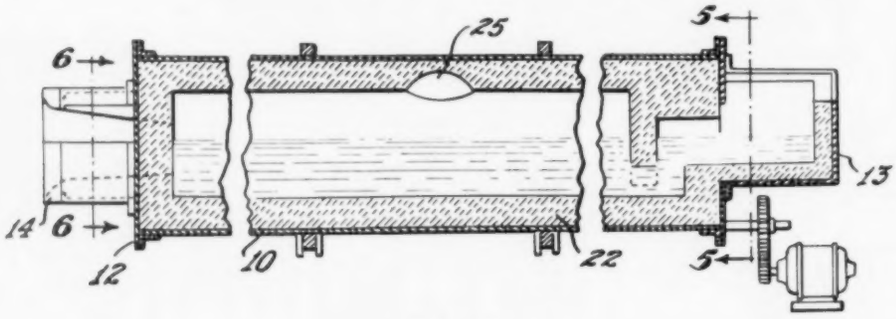


Figure 7

The blowing vessel is provided with an exhaust opening fitted with a pipe 26; in the blowing position (see Figure 5) this pipe engages a fixed pipe 27, which leads through an aspirating nozzle 41 to an exhaust stack 40. The aspirating nozzle is supplied with air by blower 42 driven by motor 43.

A series of air holes 28 penetrate the wall of the vessel. Air is supplied to these through headers 30 by the blower 32. Oxygen nozzles 33 are mounted concentrically within the air holes 28, being supplied from oxygen manifold 34.

Thus, the blast of oxygen is surrounded by a blast of air, so that the oxygen is prevented from coming in contact with the refractory lining of the vessel.

In operation, pig iron is received from a blast furnace in a Pugh car 50. The molten iron is poured into a runner 52 by rotating the body of the car. The molten pig iron is delivered through the charging spout 13, into the blowing vessel. It flows continuously through the vessel during the blowing operation and is discharged through the spout 14 into a transfer ladle 53, by means of which it is then transported directly to the open hearth furnace.

METHOD OF HOT ROLLING STAINLESS STEEL

U.S. 2,708,379, issued May 17, 1955 to Matti H. Pakkala and John L. Scarry, and assigned to United States Steel Corp., describes a method of preparing stainless steel ingots, blooms, or billets for hot rolling. In the rolling of stainless steel ingots down to semi-finished stock such as slabs or billets, seams are often formed due to checking and cracking during rolling. These checks or cracks may be closed on further rolling, but the metal on the sides of the cracks will not unite. These defects are most apparent in stainless steels having poor hot working characteristics, that is, steels which lose ductility when they cool below about 1950 F, and therefore crack and check at this temperature. Austenitic stainless steels, such as those containing 25 per cent Cr and 20 per cent Ni fall in this category.

It has now been found that by putting a coating of ceramic refractory on the ingot before rolling, the ingot can be rolled through a number of passes directly to size without cracking or checking since the coating is sufficient to prevent an objectionable drop in temperature.

The ingot is first heated to 500-800 F and a slurry of a ceramic refractory is applied. The refractory is preferably a silicate or a mixture of silicates. The patent names several coating materials which have been used successfully. A coating thickness of about ¼ in. is sufficient to provide the necessary insulation. The coating is allowed to set, and the coated ingot is then charged to the soaking pit and heated to the working temperature of about 2400 F, after which it is rolled to size through a number of passes. The coating is readily removed at room temperature by brushing.

METHOD OF PRODUCING COPPER CLAD STEEL PLATES

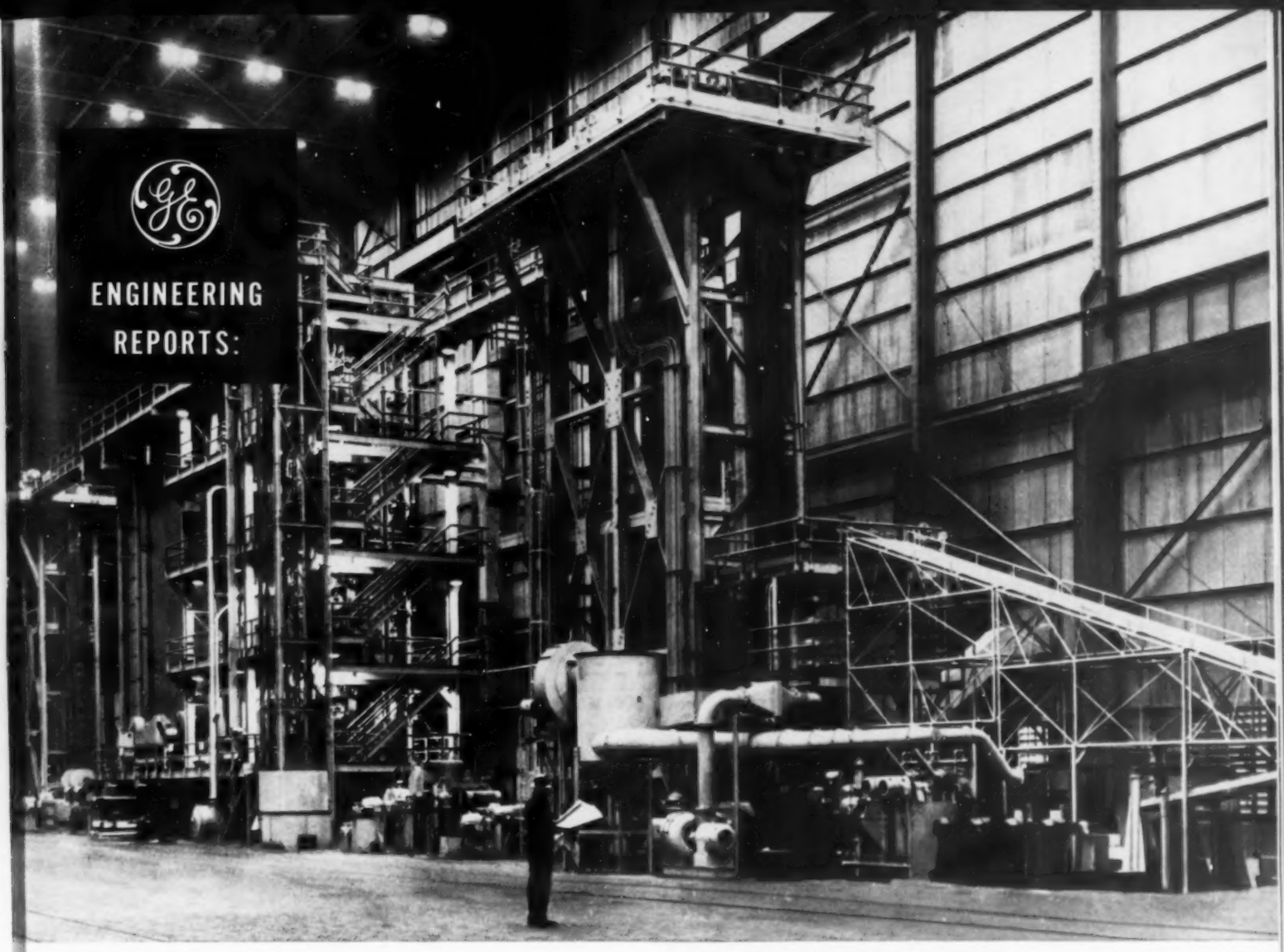
U.S. 2,707,323, issued May 3, 1955 to Thomas T. Watson and assigned to Lukens Steel Co., describes a method of manufacturing copper-clad steel plates.

An oxygen-free copper plate and a steel slab or ingot are bonded together. The copper plate may be from ⅛ to 1 in. in thickness, corresponding to thicknesses of steel from 2 to 15 in.

The method consists of electrodepositing a layer of nickel on one face of the copper plate, placing the copper plate in contact with the steel slab or ingot with the nickel-plated surface facing the steel, heating to 1550-1800 F, and subjecting to reduction in pressure rolls, the final thickness being ¼ to $^1/_{25}$ of the original thickness. The reduction in thickness per pass through the rolls is no greater than ⅛ in.; and when the thickness is within 10 per cent of the desired final thickness, the reduction per pass is no greater than $^1/_{16}$ inch.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,706,840	4/26/55	Apparatus for casting molten metal	Axel Hethey
2,707,098	4/26/55	Means for lubricating sheet metal during rolling	The Steel Co. of Wales, Ltd.
2,707,324	5/ 3/55	Casting and processing of cast metal articles	The Dayton Steel Foundry Co.
2,707,399	5/ 3/55	Blast furnace gas washer	Koppers Co., Inc.
2,707,629	5/ 3/55	Method and apparatus for heating metal parts	Frank J. Kennedy
2,707,677	5/ 3/55	Method of making steel with a low nitrogen content by the converter process	Huttenwerk Oberhausen A.G.
2,707,680	5/ 3/55	Steel adapted for hot press forging	Heppenstall Co.
2,707,813	5/10/55	Apparatus for forming seamless tubes and coating tubular sections	Sidney M. Dickson
2,708,022	5/10/55	Magnetic conveyor	United States Steel Corp.
2,708,107	5/10/55	Work conveyor mechanism for heat treating furnaces	Holcroft & Co.
2,708,159	5/10/55	Heat treated, hardened alloy steel elements	The International Nickel Co., Inc.



G-E VERTICAL ANNEALING FURNACE at Fairless Works is one of largest in world. Strip is annealed at rate of 1000 fpm

Drive-engineered by General Electric . . .

New Fairless line anneals 30 tons/hr

Running at speeds up to 1000 feet per minute, U. S. Steel's new cleaning and annealing line at their Fairless Works, Fairless Hills, Pa., produces clean, bright, uniformly annealed strip at the rate of 30 tons per hour. This continuous processing line is a typical example of the drive-engineering and equipment applied to many of the new Fairless lines by General Electric.

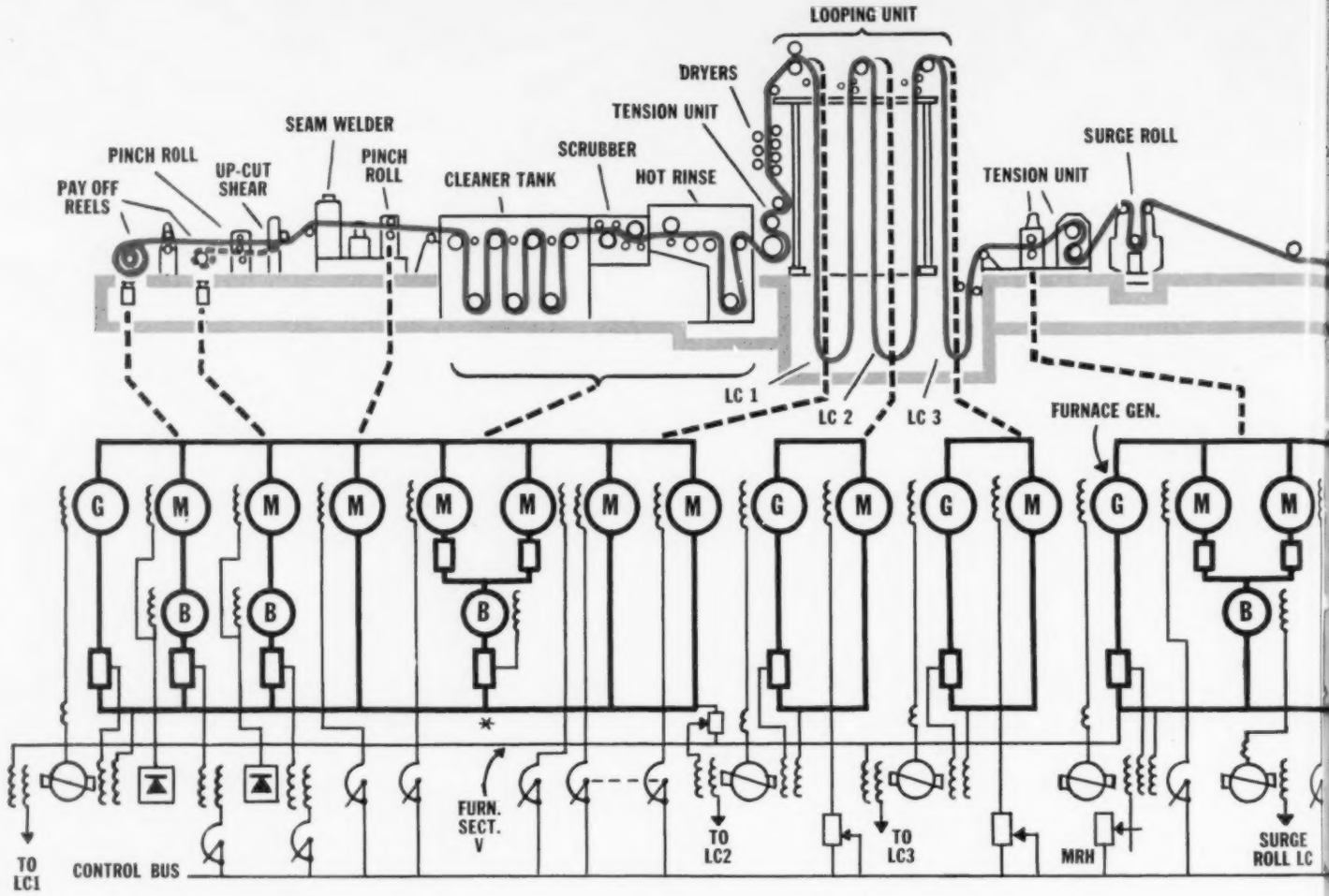
It is also another example of the teamwork performed between the customer, his machinery builder, and General Electric. Engineers from U. S. Steel, United Engineering and Foundry Co., and General Electric worked together to design this annealing line which is one of the fastest in operation today.

The entire line operates under automatic control, and handles strip from 18 to 37 inches wide. The use of a G-E annealing furnace—one of the world's largest—and vertical loops permits the accommodation of 3000 feet of strip between the two ends in a floor length of only 385 feet.

The same G-E engineering skill which was utilized on this high-speed annealing line is available to you. If you are planning to build, expand, or modernize your facilities, contact your Apparatus Sales Representative at the nearest G-E Apparatus Sales Office. General Electric, Schenectady, N. Y. 659-107

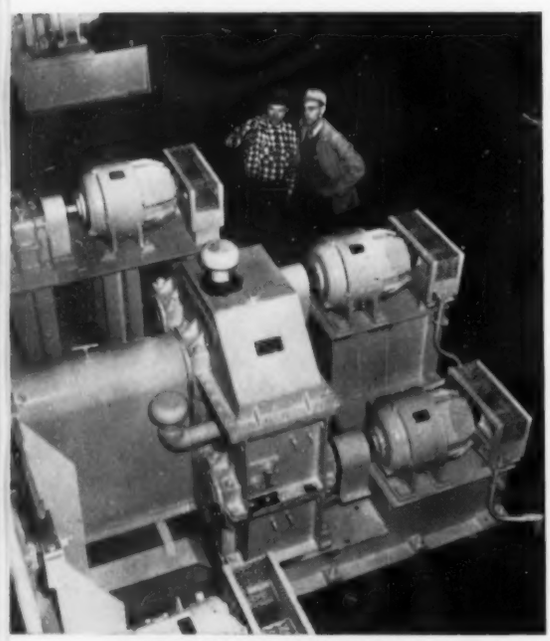
ADVANTAGES OVER BATCH METHODS

GENERAL ELECTRIC

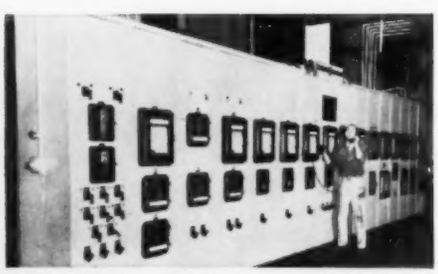


Powered by a General Electric drive system . . .

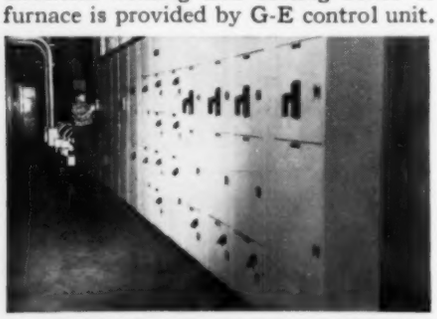
New Fairless continuous annealing line



ADJUSTABLE SPEED G-E d-c motors on tension bridle help maintain constant strip tension in furnace.



AUTOMATIC CONTROL of gas fired and electrical heating and cooling zones of furnace is provided by G-E control unit.



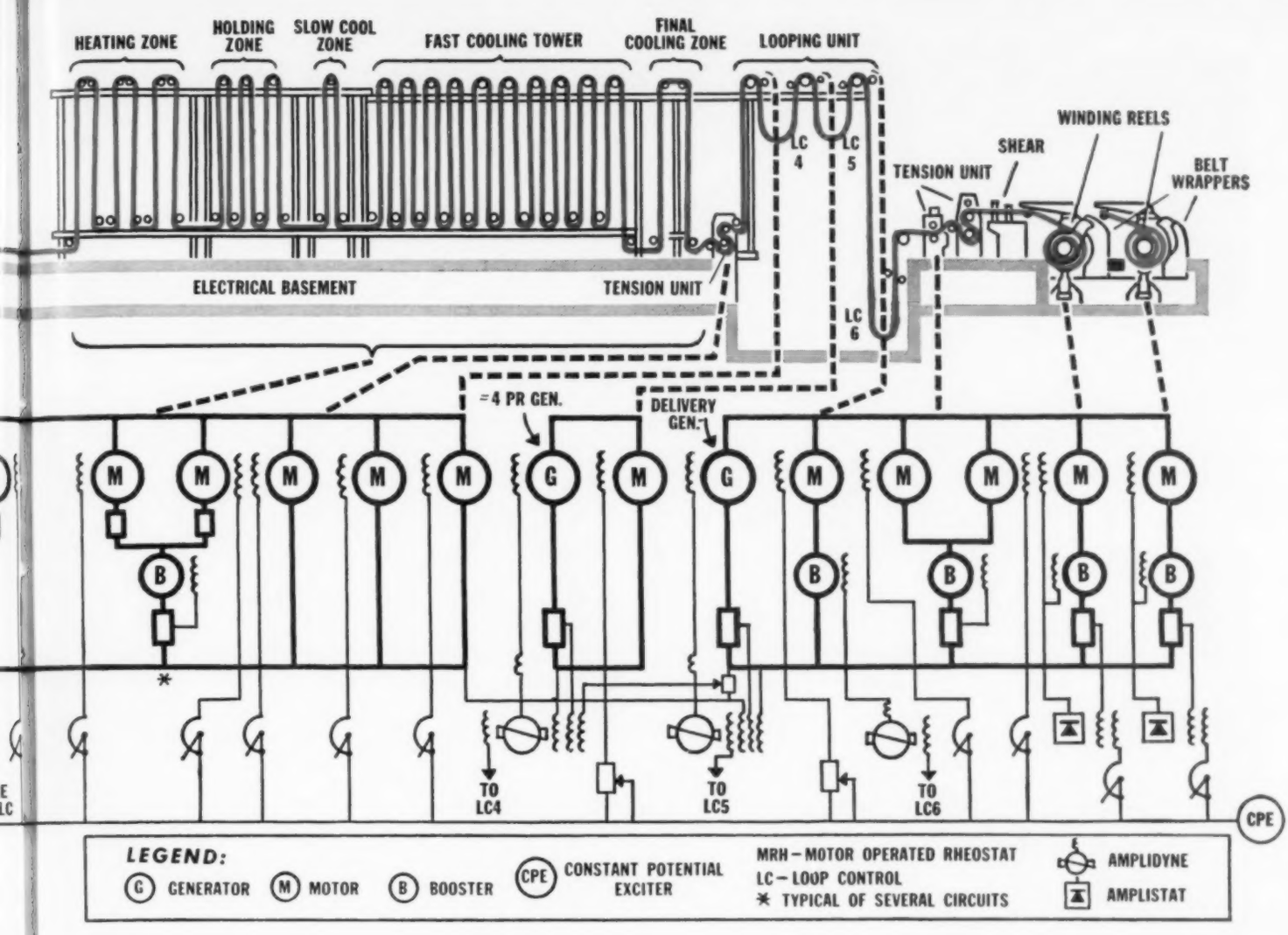
COMPACT G-E control center for fans, pumps, and auxiliary m-g sets is located in electrical basement.

HOW THIS DRIVE WORKS

A motor-operated rheostat sets line speed by controlling the furnace-section generator voltage. Voltages of the entry and delivery section drives, and the tower pinch rolls, are regulated to keep the entry storage loops full and the delivery storage loops empty during normal running. The furnace-section voltage is used as a reference for an approximate speed match, with the photoelectric loop controls (LC) acting as over-riding vernier regulators to maintain accurate loop position.

To start a new coil, the entry section is decelerated to a stop under current limit, while the "half-speed pinch roll" (No. 1PR) empties the loops evenly. This permits the strip to continue through the furnace at a constant speed during the time required to weld toegther the ends of the new and old coils. The entry section is then accelerated, again under current limit, to an overspeed condition until the storage loops are refilled. Full coils of annealed strip are removed from the delivery end of the line in a corresponding manner.

Another example of G-E drive engineering at work!



has 5 advantages over batch methods

1 **Increases output** **2** **Improves product** **3** **Saves time**

4 **Saves manpower** **5** **Saves space**

Fairless' new continuous cleaning and annealing line at Fairless Hills, Pa., is an excellent example of the progress that has been made in the continuous processing field. Powered by a General Electric drive system, the new line, which can process 30 tons of steel per hour at speeds up to 1000 fpm, has these five advantages over batch methods.

1. **INCREASES OUTPUT.** Continuous high-speed operation of line 24 hours a day speeds output.
2. **IMPROVES PRODUCT.** Precise temperature control of furnace gives strip greater uniformity, with improved flatness, and cleaner surface.
3. **SAVES TIME.** High speed of line reduces coil annealing time from days to minutes. There is no need to transport coils from cold mill to cleaning unit to furnaces.
4. **SAVES MANPOWER.** Amplidyne control of tension, loop positioning, and overspeeding provides high degree of automatic operation.
5. **SAVES SPACE.** By combining cleaning and annealing, floor space is reduced by more than a third.

You also profit when you specify General Electric to help design your continuous processing line electrical systems. Experienced G-E steel mill processing line engineers are available to work with you and machinery manufacturers to construct modern, high-speed lines. For further information, contact your G-E Apparatus Representative, or write for bulletin GEA-6017, "Engineered Electrical Systems for Continuous Metal Processing." General Electric Co., Schenectady, N. Y.

659-107

Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC

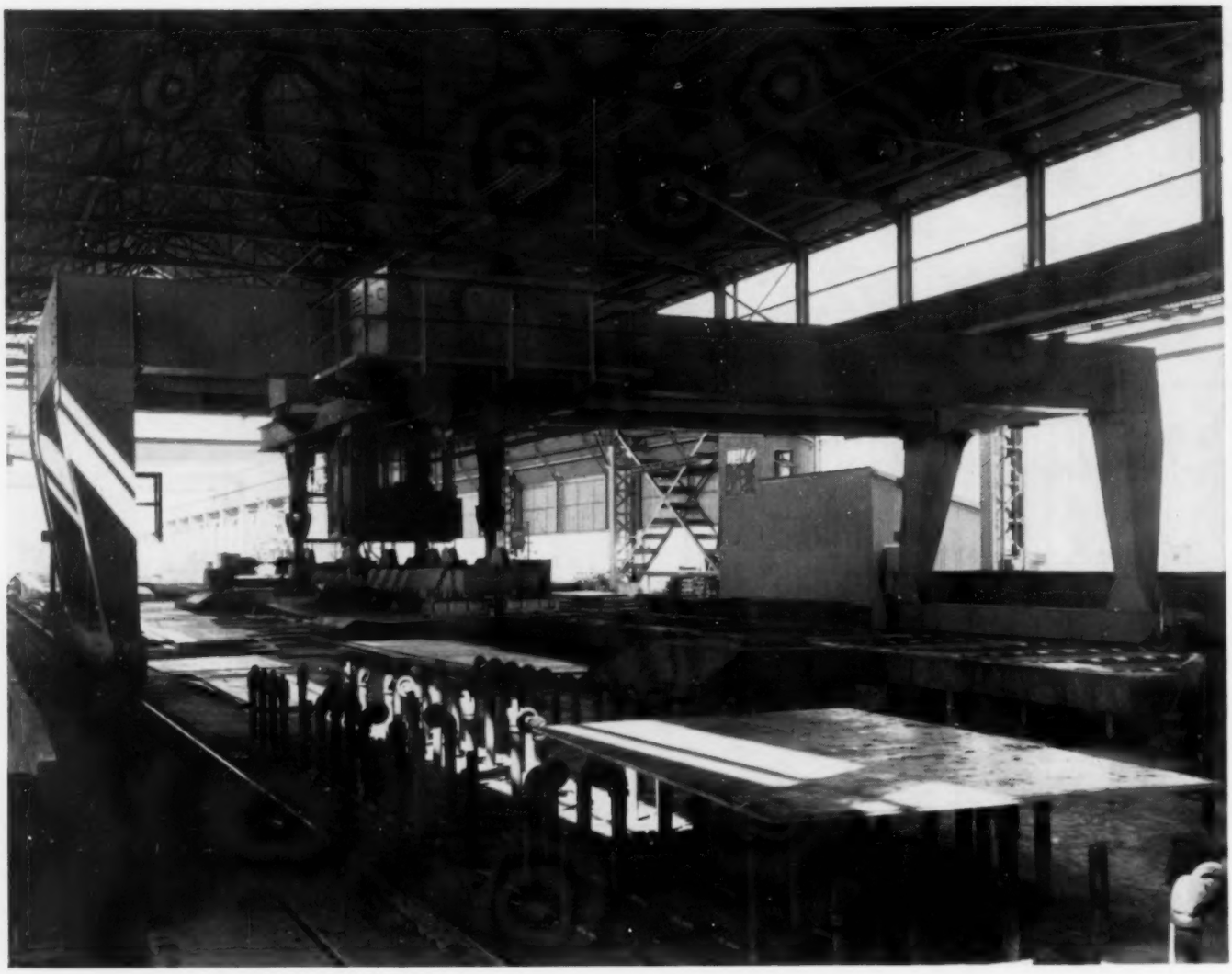


PLATE HANDLING GANTRIES . . . *by "Shaw-Box"*

Plate Handling Gantries are another specialty in the broad "Shaw-Box" Line of Steel Mill Cranes. Ruggedly built to give dependable service, they contain many exclusive mechanical advantages and features which give fast operation at lowest cost. Here are a few of these advantages — variable flux control (patented), lifting magnets that discharge one plate at a time after picking up several, rope lifts with guides to restrict swing of the load.

In "Shaw-Box" Plate Handling Gantries — whether built to an individual mill's or A.I.S.E. specifications — you get the added advantages that come from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. These added advantages insure crane performance which makes "Shaw-Box" Gantries, for the work they do, the least expensive cranes to buy and use!

SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

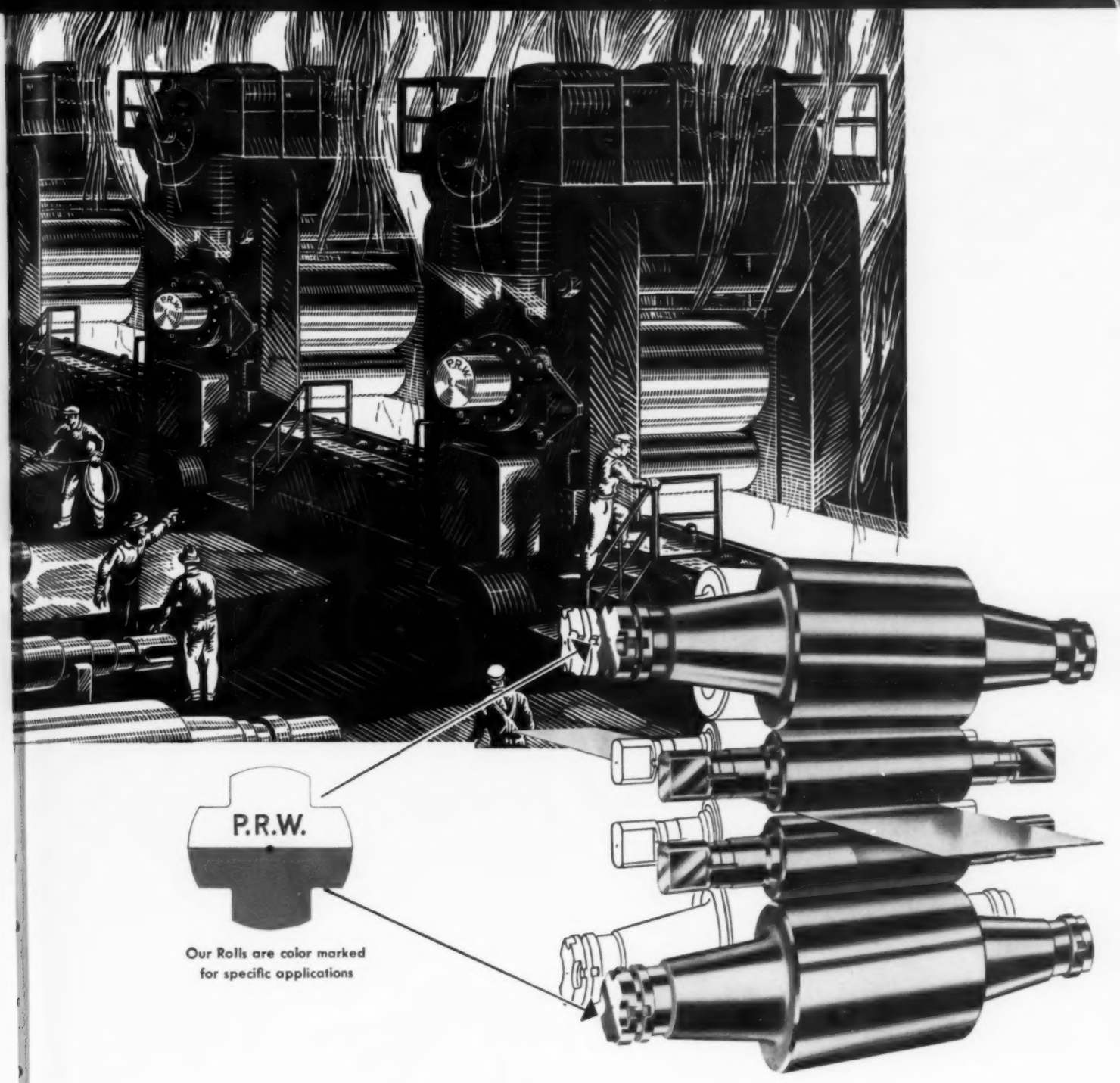
MAXWELL MANNING MMM MOORE TRADE MARK

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' Industrial Instruments and Aircraft Products.



The right roll in the right stand

... *means less down time on the mill*

Engineering, design and application service are readily available to you through our roll engineers ... who combine practical experience with technical know-how ... in the selection of the *right* roll for *each* application in your mill.

PITTSBURGH ROLLS

BLAW-KNOX

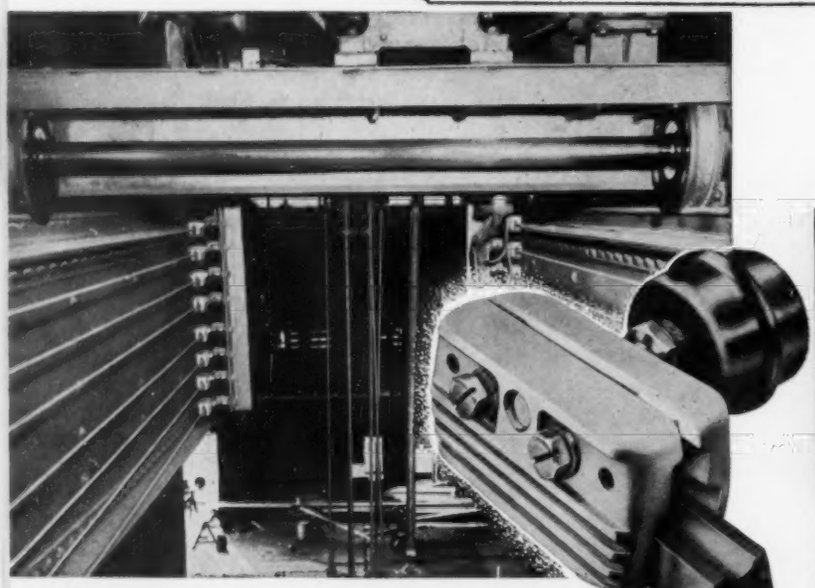
BLAW-KNOX COMPANY • ROLLS DIVISION • PITTSBURGH ROLLS DEPARTMENT
PITTSBURGH 1, PENNSYLVANIA

PITTSBURGH ROLLS: Chill • Sand • Moly Chill • Special Rail Finishing • Phoenix "K" • Sandalov • Pittsburgh 25 • Pittsburgh 35 • Pittsburgh 45 • Pittsburgh 55 • Pittsburgh Special Process • Phoenix 25 • Phoenix 35 • Phoenix 45 • Phoenix 55 • Phoenix Special Process • Phoenixloy • Phoenix Metal • Phoenix Metal Special • Phoenix Metal "F" • Phoenix Metal Master • Carbon Steel • Phoenix "A" • Phoenix "A" Special • Piroco • Piroco "A" • Piroco "B" • Piroco Special • Herculyte

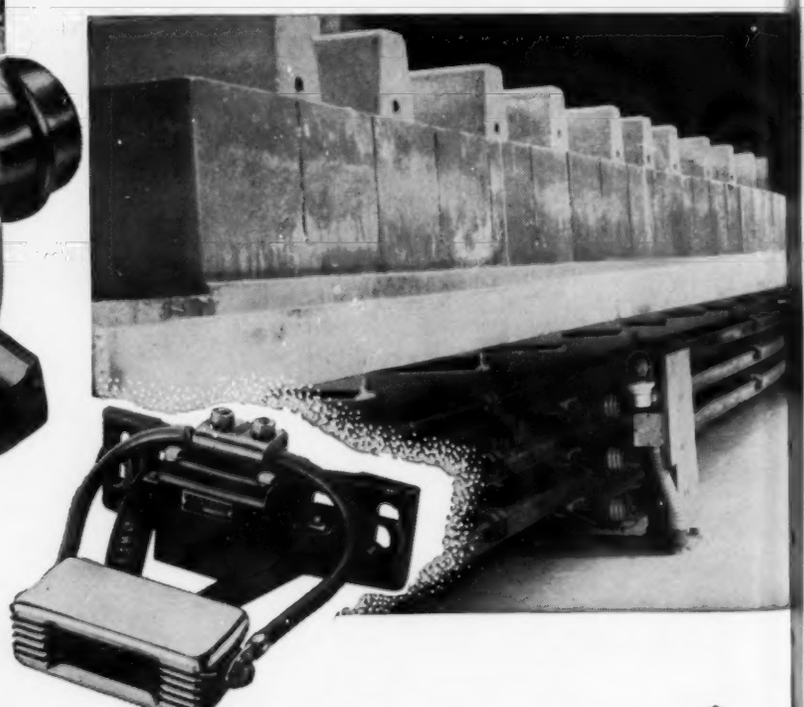
Drop all your

The ELECTRIC SERVICE

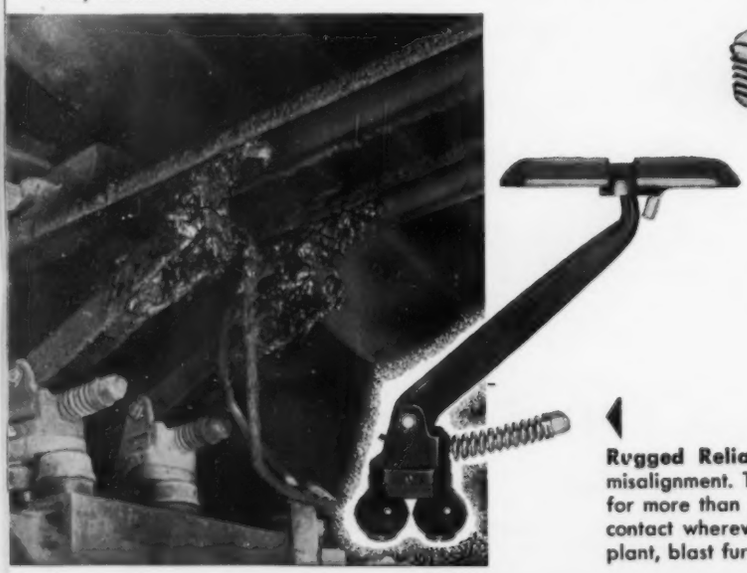
1. Design New
2. Modernize
3. Recommend



More Usage, Less Wear for Keystone XVI Crane Trolley Collectors. Installed on an overhead crane the same day wheel-type collectors went on a similar crane, they were in operation 50% longer each day. When wheels were removed due to failure, the XVI renewable carbon shoe contact inserts still had many months of life ahead.



Long, Hard, Hot Service at Birdsboro Steel Foundry & Machine Co. Loaded furnace cars move in and out of heat treating furnaces safely and without a hitch. Rails on each furnace car contact stationary columns equipped with Keystone LMI Pony-size Contact Rail Collectors. These reversible collectors offer 30% greater contact travel, efficient current transfer.



Rugged Reliability in the face of dirt, rainy and icy conditions, and severe misalignment. These Keystone Inverted-V Universal Collectors have operated for more than seven years at the Alan Wood Steel plant. They give positive contact wherever the going is rough, tough, and dirty—in open hearth, coke plant, blast furnace.

ELECTRIC SERVICE MANUFACTURING CO.,

third-rail

problems on his desk!

Engineer will collaborate and . . .

Keystone Conductor System (Steel, Aluminum or Copper)

your Present System for Greater Efficiency and Economy

Suitable ESM Equipment for the Job

INDUSTRIES rely heavily on the Electric Service engineer for designing or converting power Conductor Systems. There are three main reasons:

ESM ALUMINUM, STEEL, COPPER SYSTEMS—All three are designed and built by Electric Service. Each has its proper applications, resultant economies. The system specific to *your* needs is recommended without bias.

ESM SERVICE IS COMPLETE—Engineering counsel is backed up by the complete line of Keystone Equipment and by ESM installation specialists. Electric Service engineers new systems, modernizes inadequate systems, repairs existing systems.

ESM PRODUCTS ARE JOB-PROVED—They're at work on all types of materials handling equipment in every industry—steel mills, power plants, docks, rail yards, processing plants. Typical installations shown here illustrate the scope and reputation of Electric Service in this electrical power-transmission field.

What's your problem?—insufficient power? . . . severe weather or corrosion conditions? . . . production-sapping shutdowns? . . . excessive maintenance? Write today for assistance.

Aluminum Reduces Corrosion, cuts deadweight for Canton Co. Baltimore Harbor's salty dampness doesn't faze Keystone Integrated Aluminum Conductor System. High-speed ore unloader utilizes aluminum on trolley conductors and on 1200-ft., 2300-volt main runway. Aluminum Under-running System has high current capacity, low voltage drop, sensitive control.

Unhurt by Volts, Jolts are the Keystone Insulators on Fairless Works coke oven rails. Petticoat-type Porcelain Insulators resist contamination by dirt, moisture. Shock-proof, non-absorbent moulded type Insulators team up to protect over-running contact rails under severe conditions.

KEYSTONE
INDUSTRIAL
POWER
PRODUCTS

Philadelphia 32, Pa.

Represented in Canada by Lyman Tube and Bearings, Ltd., Montreal and Toronto

TYPE F
STEELFLEX
COUPLING

- Any Size
- Any Service
- Any Application, Horizontal or Vertical
- Always available

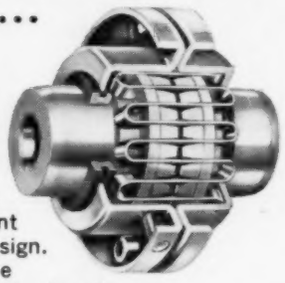
The exclusive grid-groove design of FALK Steelflex Couplings protects your machinery in two ways

You get double protection when you connect your driving and driven machinery with a Falk Steelflex Coupling—the all-steel-built coupling with the exclusive grid-groove design! First, its torsional resilience smothers shock and vibration; and second, the Steelflex design prevents damage and lowered efficiency by accommodating shaft misalignment.

Why have increasing numbers of key men in industry standardized on Falk Steelflex Couplings? Their experience has proved that Falk Steelflex Couplings prolong the service life of their machinery...are trouble-free and need minimum maintenance...are easy to install, lubricate and disconnect ...and cost less per year of service than ordinary couplings.

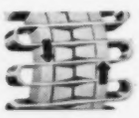
One basic Steelflex design—the Type F, in its many sizes—is adaptable to more than 90% of all industrial applications. This facilitates buying, as well as prompt replacing and servicing when necessary. Write to Department 247 for engineering bulletin, including selection and dimension details.

How shock and vibration are smothered by the FALK Steelflex Coupling's Torsional Resilience...

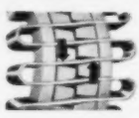


This cutaway view shows the sturdy all-steel construction, also the exclusive, torsionally resilient grid-groove design. Here is how the grid-groove design functions:

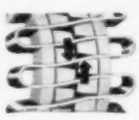
UNDER LIGHT LOADS The gridmember bears only at outer edges of grooves. The long span between points of contact remains free to flex under load variations.



UNDER NORMAL LOADS As load increases, the distance between supports on grooves is shortened proportionately, but a free span remains to cushion shock loads.

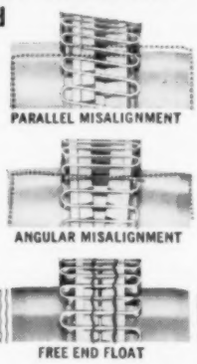


UNDER SHOCK LOADS Under extreme overloads, the gridmember bears fully on the grooves and transmits full load directly. The coupling remains flexible, within its rated capacity.



SHAFT MISALIGNMENT ACCOMMODATED
Free End Float Permitted

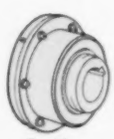
Controlled flexibility in the FALK Steelflex coupling provides compensation for parallel and angular shaft misalignment—and permits free end float for the shafts of the driving and driven members, or of either one.



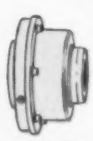
PARALLEL MISALIGNMENT

ANGULAR MISALIGNMENT

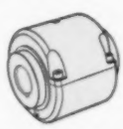
FREE END FLOAT



Rapid
CM—Reversing
Service



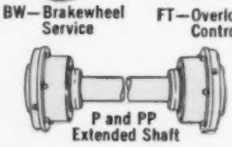
H and HH
High Speeds



FS—Limited Space

BW—Brakewheel
Service

FT—Overload
Control



P and PP
Extended Shaft

OTHER TYPES AVAILABLE

In addition to the standard Type F (which meets more than 90% of all applications), special or dual purpose Steelflex designs are available for unusual applications. A few of the many types are shown here.

THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

RIGHT ANGLE
Roller
Ends

RIGHT ANGLE
Bearing
Surfaces

RIGHT ANGLE
Separator
Slots

Longer operating life? Right!
Less maintenance? Right again!

Heavy-duty equipment "rolls right" with Rollways because . . .

. . . solid cylindrical rollers provide the long line-contact required by heavy loads.

. . . precisely made ends, bearing surfaces and retainer slots restrict end-rub, skew and side-shock.

. . . special alloys in the races resist spalling and brinelling.

It all adds up to a bearing that rolls longer, takes less maintenance, prolongs the life of your equipment.

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Quality Products Designed For
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CASE HISTORY

Mill Table

No Maintenance Charges — No Down Time
Minimum Make-Up

Initial installation of 5 Drums GEARKOTE still functioning compared to consumption of 56 Drums of another product during a 19 week period.

NOMELT
DENSOIL
METALICOIL

GEARKOTE
NONSEPARA
METALICGREASE

PRODUCT NAMES GEARKOTE, NONSEPARA, METALICOIL AND METALICGREASE ARE REGISTERED TRADE MARKS OF THE HODSON CORPORATION

The HODSON CORPORATION

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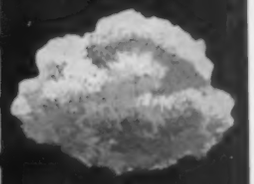
Let this be your eyes...

...where it's too hot



...behind dangerous barriers

...inaccessible locations

where you can't get close!

In more and more steel plants, power stations, and other industries, RCA Closed-Circuit Television is performing jobs that save thousands of dollars annually by preventing injury to personnel, lost time, or damage to products.

In the comfort of your office or enclosed control booth, your Industrial TV monitor can bring you a clear, high-resolution picture of all the information you need. The camera gets up close and stays continually on the job without attention. It looks in furnaces and boilers, follows processes, reads instruments, and provides control of many other functions that help protect your company's profits.

Engineered to your own particular requirements, RCA Industrial TV can be furnished with special housings and water-cooled windows to make it suitable to the most rugged conditions. And the RCA Service Company makes installation and service available wherever you are. Why not find out more today about the benefits you can obtain from RCA Industrial TV?

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☐ Please send me additional information on the profitable use of RCA Closed-Circuit Television in industrial applications.

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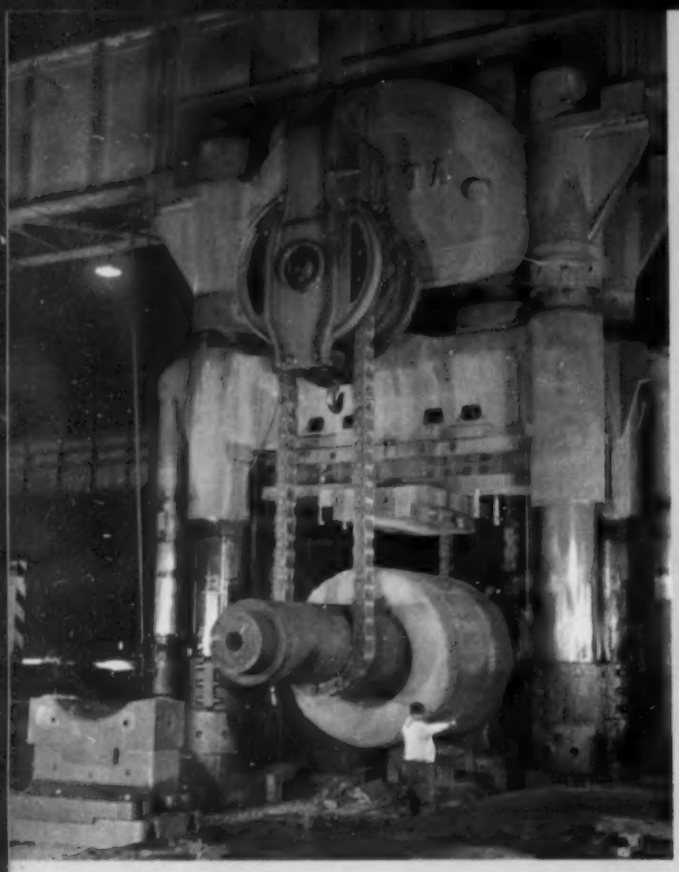
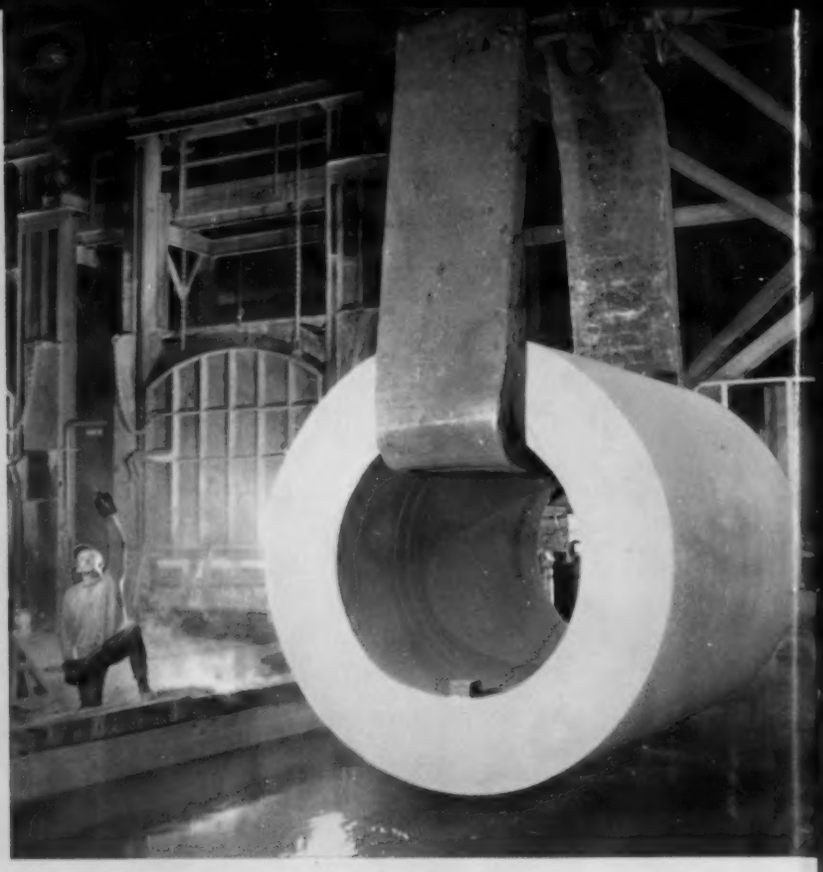
Address_____

City and State_____



Here, one of the cylinders is being forged on the 7,000-ton press. Masterful work on the mandrel and precision manipulation of the press provide proper thickness/diameter ratio.



The cylinder (largest of its kind ever forged) is about to be lowered into the water quench tank after heat treating.

GE gets ready to make some big crashes

General Electric's Large Steam Turbine-Generator Department recently installed a high-speed burst pit to investigate the bursting characteristics of wheels and rotors. Model forged turbine and generator shafts and other partial and full scale parts will be spun at speeds up to 25,000 rpm or until they burst.

The big burst pit includes two concentric forged steel cylinders, made by the Homestead Forgings Division of U. S. Steel. These 60-ton cylinders must possess a strength that almost defies description because tremendous forces are at work here.

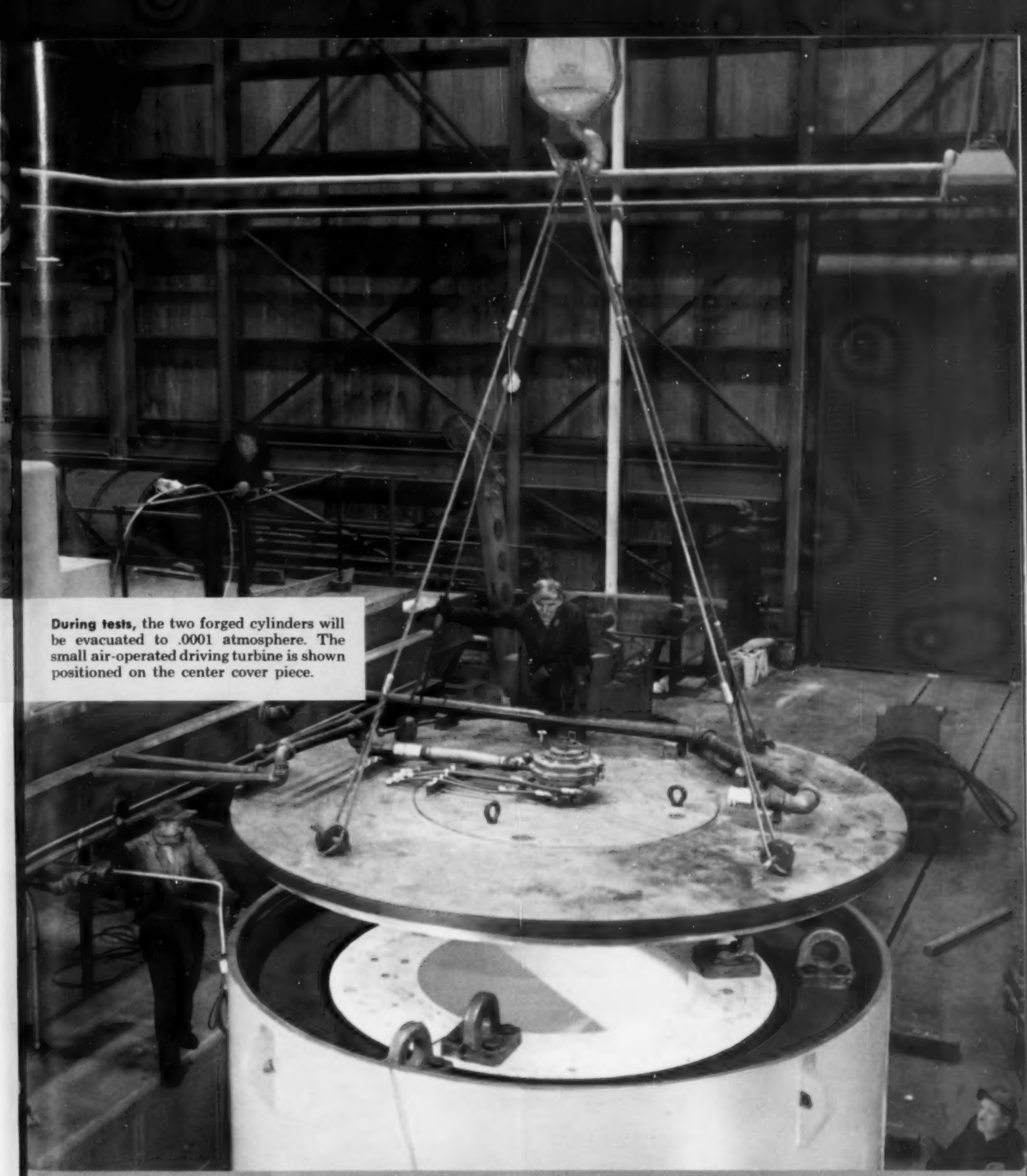
Imagine 200 automobiles traveling 100 mph crashing simultaneously. These U. S. Steel Quality Forgings have been designed to absorb that same amount of energy (200 *million* foot pounds).

With this testing facility, General Electric engineers expect to learn new things about material strength and rotor design which will permit building ever-better turbine-generator units to keep up with the demand for low-cost electric power.

U. S. Steel's Homestead Forgings Division produces a complete range of high-quality forgings, including turbine-generator shafts, heavy machinery parts, and giant sleeves like GE is using in this burst pit. We solicit your inquiries or requests for our free booklet on USS Quality Forgings. Just write to United States Steel, 525 William Penn Place, Room 4799, Pittsburgh 30, Pa.

SEE **The United States Steel Hour.** It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL



During tests, the two forged cylinders will be evacuated to .0001 atmosphere. The small air-operated driving turbine is shown positioned on the center cover piece.

USS

Quality FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- forged steel rolls and back-up roll sleeves
- electrical and water wheel shafts
- hammer bases and columns

NEW! Heavy-duty relay in small space

This new CLARK Type "PM" Control Relay introduces a new concept in relay design: *Sectional Pole Construction.*

In this new relay, each pole is contained in its own melamine housing, and any individual pole can be removed or replaced from the front without disturbing the others. A short circuit is confined to a single pole and will not destroy the whole relay. Wiring terminals are on the front, and all maintenance including coil changing, pole or magnet replacement, is also from the front—without removing relay from panel. Contacts are quickly and easily convertible from normally open to normally closed and vice versa—from the front. Range of models provides relays with 2 to 12 poles. Exclusive design allows more contacts per square foot of panel space. In addition to the many advantages of SECTIONAL POLE CONSTRUCTION, you get a *heavy-duty relay in small space.*

For complete information write to

The CLARK CONTROLLER *Company*

Engineered Electrical Control

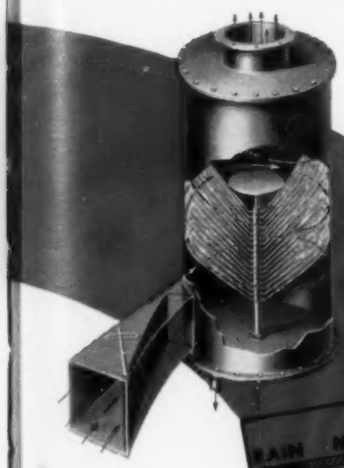
1146 East 152nd Street • • Cleveland 10, Ohio

SEE THIS NEW RELAY AT THE CLARK EXHIBIT, PRODUCTION ENGINEERING SHOW, BOOTH 840
Navy Pier, Chicago — September 6-16, 1955

The first 2 steps to eliminate

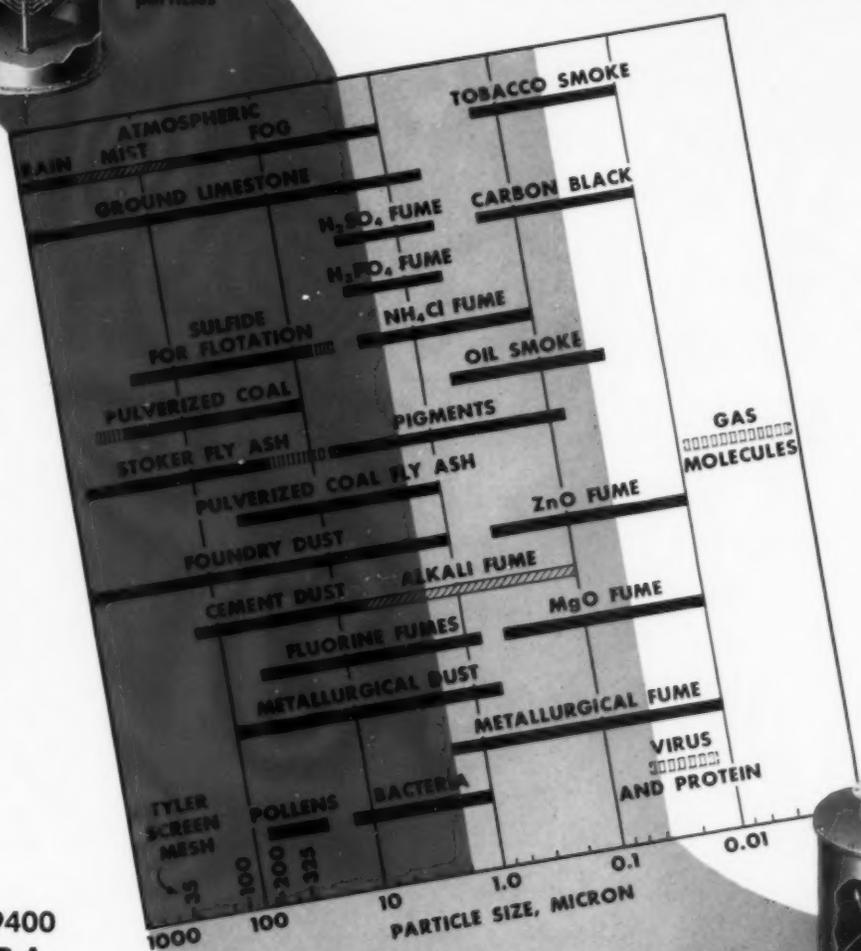
DUST or FUMES

in your plant



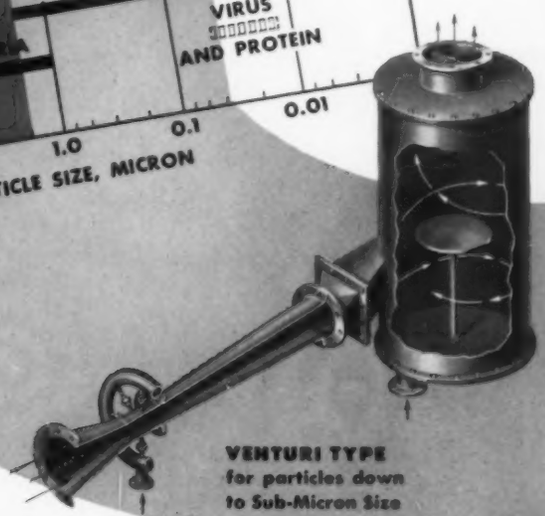
CYCLONIC TYPE
for Micron size particles

1 Pick out your dust or fumes in this chart of particle sizes to determine the type of P-A Scrubber to be used



2

Phone LO 4-9400 or write our P-A Sales Dept. for further information, and ask for our Bulletin M102 on Pease-Anthony Gas Scrubber



VENTURI TYPE
for particles down to Sub-Micron Size

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A Unit of American Cyanamid Company
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CHEMICO (P-A) **SCRUBBER**

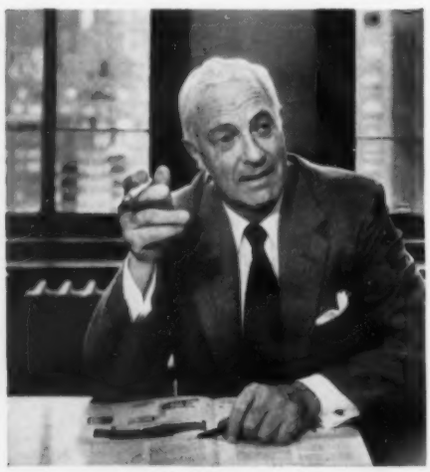
CC279

CHEMICO

CHEMICO CHEMICAL CONSTRUCTION CORPORATION

How Do Lightweight Refractories Cut Fuel Costs And Boost Furnace Output?

Here, certainly, is a timely question. There's a heavy squeeze today on most furnace operators for lower costs, larger production . . . or both. And despite all the economies they've put into effect so far, they're still searching hard for ways to make their furnace dollars do a bigger job.



The following discussion brings out a number of facts, often overlooked, about the money-saving, profit-building potentials inherent in *lightweight* insulating firebrick.

Q. *First of all, just what do you mean by "lightweight" insulating firebrick?*

A. Compared with dense, fireclay brick weighing approximately 7½ to 8½ pounds each, insulating firebrick range from about 3½ pounds down to slightly over 1 pound for various temperature requirements.

Q. *What does this light weight have to do with lower production costs?*

A. Briefly, heavy furnace linings waste your fuel dollars two ways:

They soak up and store large quantities of heat which are lost when the furnace is cooled; and they conduct and lose too much heat through the wall.

Lightweight insulating firebrick, on the other hand, contain millions of tiny air cells, heat up and cool quickly, absorbing and storing very little heat. Also, they resist heat flow, keeping it inside the furnace to do productive work.

Q. *I can see why you would save on fuel — but how much?*

A. There's no single answer to that question — there are too many variables to be considered. But to give you an idea of these savings, here are a few actual examples:

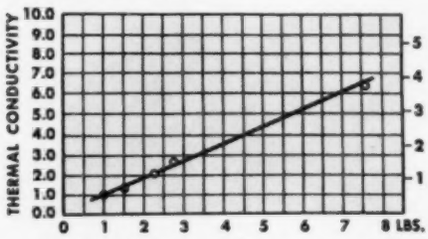
The operator of a large forge furnace cut his fuel costs more than 50% after changing to *lightweight* insulating firebrick.

A manufacturer of electric kilns states that insulating firebrick result in heat savings of fully 25%.

A magnesium melting crucible furnace that formerly used 1,000,000 BTU's per hour now does the same job with 500,000 BTU's, thanks to insulating firebrick.

Q. *Increased production has also been pointed out as an advantage of insulating firebrick. How do you explain this?*

A. Again the answer lies in lightness of weight. Because lightweight firebrick store and conduct less heat, they come up to operating temperature faster — cool down faster, too. This means — shorter heating cycles.



Relation between weight and thermal conductivity for several brands of kaolin base refractories. (mean temperature, 900F)

Secondly, because lightweight firebrick conduct far less heat than heavy, dense firebrick, you don't have to build as thick a wall. This gives you more hearth area per square foot of floor space.

Thirdly, lightweight firebrick respond more rapidly to changes in furnace heat input, which means closer temperature control and fewer rejects in many instances.

It's just like adding extra furnace capacity without adding to your furnace investment.

Q. *Are there any differences in the performance of the various brands of insulating firebrick available?*

A. Naturally, the *lighter* the brick the greater the fuel savings and furnace output. And the lightest insulating firebrick of all, for any temperature range — if you'll pardon our mentioning it — are B&W Insulating Firebrick.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga. R-508

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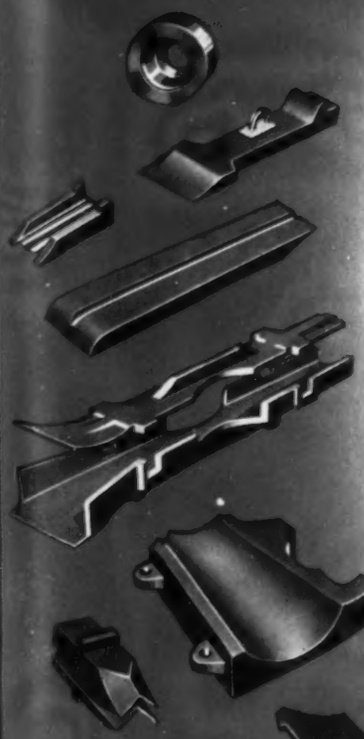
YOUNGSTOWN ALLOY CASTING CORPORATION

CELEBRATING 20 YEARS

OF SERVICE TO THE STEEL INDUSTRY

1935—1955



20-Year-Users find that "TRANTINYL" Alloy Steels have no equal—in tonnage rolled over one set of guides.

ROLLING MILLS:
bar, hoop, strip, shape mill guides, and rollers

SEAMLESS TUBE MILLS:
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ELECTRIC WELD TUBE MILL:
forming rolls, planishing rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

Youngstown Alloy Casting Corporation

Youngstown, Ohio

Any Size . . . Any Type

This is one of the many types of forged rolls produced by Bethlehem during the course of a year. It is 21 ft long, has a body length of 12 ft 1 in., and weighs 12¼ tons. You might call it a light-heavyweight, for we make some that are bigger and many, of course, that are smaller.

Whatever your own requirements in rolls, our shops can meet them to your entire satisfaction. At Bethlehem, specifications on size, finish, and hardness are faithfully adhered to. Even the most minor points receive complete attention.

When rolls are needed again for your mills, we hope you'll invite us in to talk about it. Rest assured, our people will co-operate in every way. Check with us, won't you?

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Cold-rolling ferrous sheets and strip

Running-down and finishing operations on copper and brass sheets

Hot- and cold-rolling aluminum sheets

Cold-rolling aluminum foil

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Colorful cans, gleaming bottles, eye-catching cartons riding in the cart—not a single one of them would be there were it not for refractory brick. Brick that makes steel. Brick that makes glass. Brick that makes paper.

Everything that's made and everything that's moved starts with refractory brick in one form or another, lining the furnaces of industry. The requirements are almost infinite in variety.

To provide the truly complete refractory service that industry needs, General Refractories employs the world's largest refractories research laboratory; brings materials across oceans; manufactures in plants strategically located to serve industry swiftly . . . dependably . . . economically . . . everywhere.

GENERAL REFRACTORIES COMPANY, Philadelphia 2

GENERAL REFRACTORIES

COMPLETE REFRACTORIES SERVICE

FOR THE METALS INDUSTRY . . .

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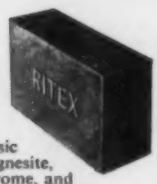


RITEX—
Unburned basic brick—in magnesite, magnesite-chrome, and chrome-magnesite. More resistant to spalling. Lower porosity, lower thermal conductivity—high hot strength.

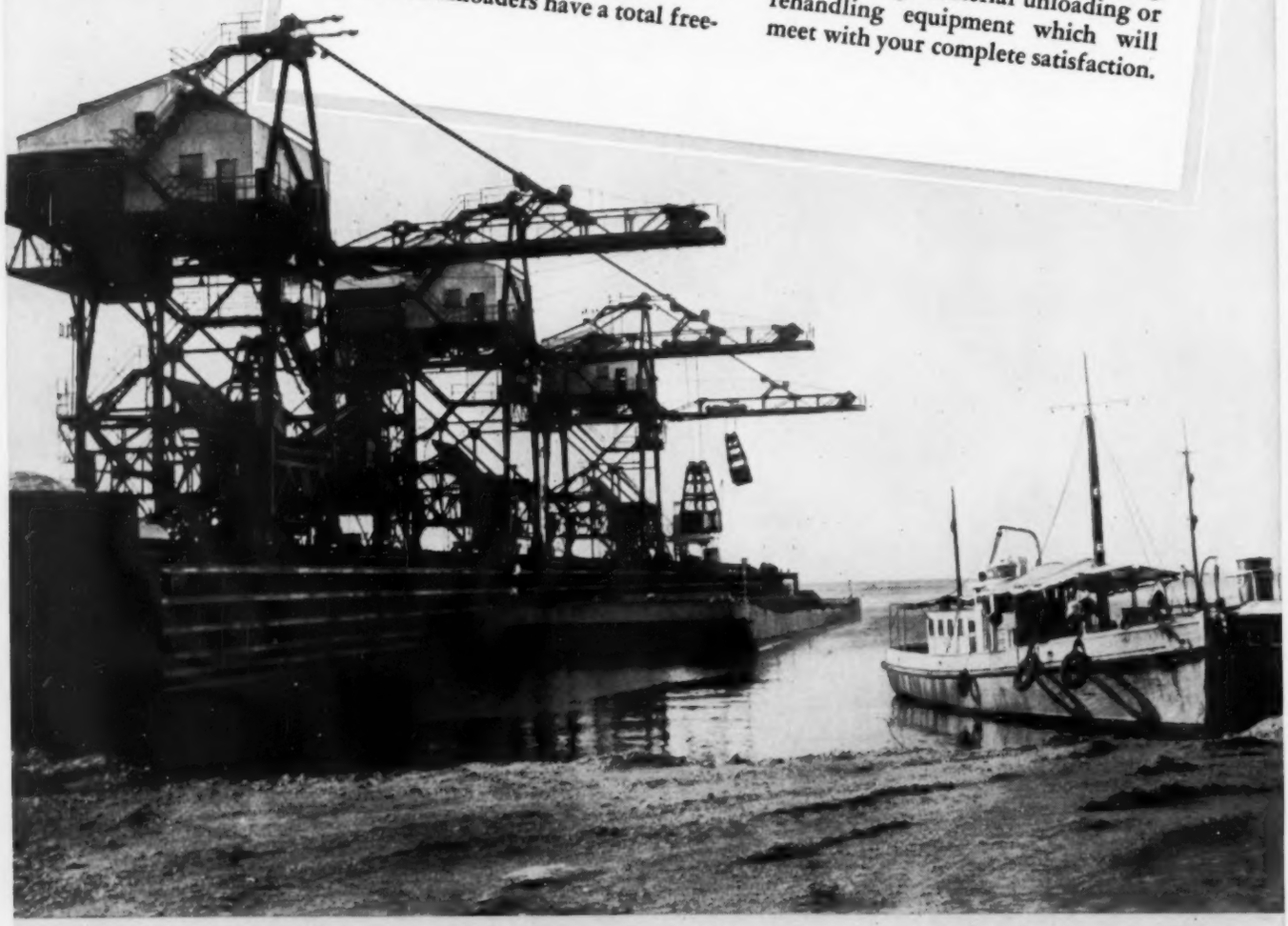
STEELKLAD
—A Ritex basic brick, permanently jacketed in a patented steel shell. Just one of many superior GREFCO products.

Unloading Venezuela Ore

These three Mead-Morrison unloaders, installed in 1949 at Puerto de Hierro, Venezuela, are a vital link in the material handling system transporting ore from the mine to steel plants in the U. S. The towers unload ore from river boats on the Orinoco River and deposit it on conveyor belts which transport the ore to stock piles to await shipment on ocean-going vessels.

The 8-ton unloaders have a total free-digging capacity of 3,000 tons per hour and were built of special alloy steel, to reduce weight and withstand earthquake shocks which occasionally occur in this locality.

Whatever your particular conditions may be, you can depend upon Mead-Morrison experience and engineering skill to design material unloading or rehandling equipment which will meet with your complete satisfaction.



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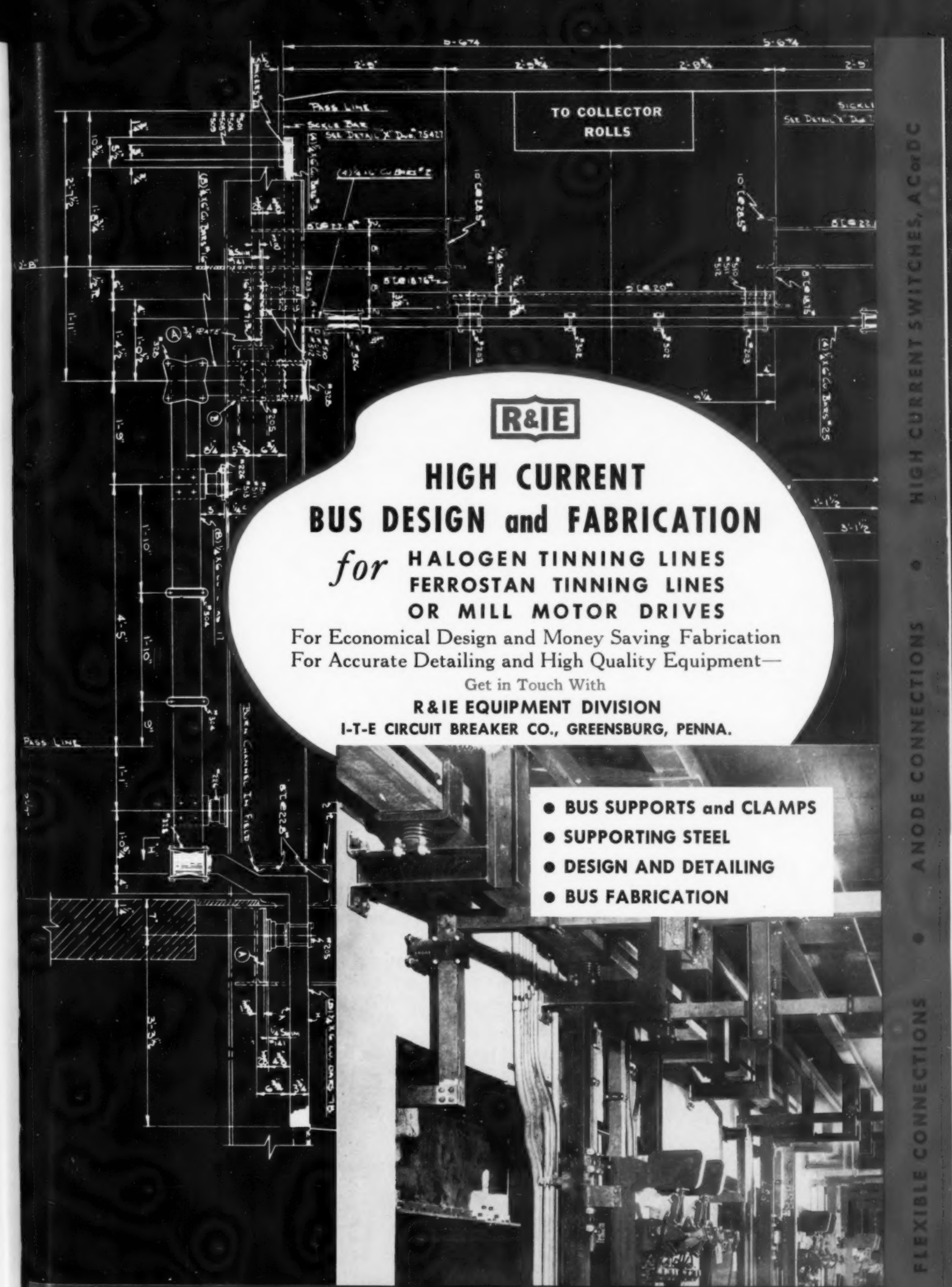

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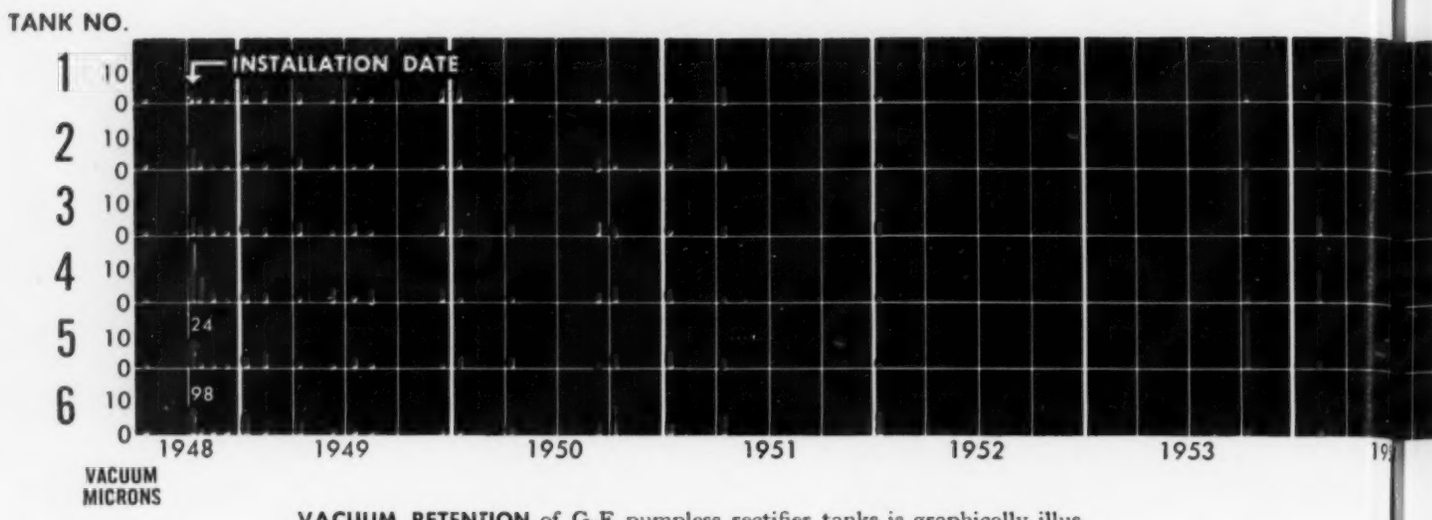
- BUS FABRICATION

FLEXIBLE CONNECTIONS • ANODE CONNECTIONS • HIGH CURRENT SWITCHES, ACorDC

BUS DESIGN, DETAILING and FABRICATION • BUS SUPPORTS CLAMPS



VACUUM RETENTION of G-E pumpless rectifier tanks is graphically illustrated here. None of these six tanks, installed almost seven years ago at the Buffalo plant of the Wickwire Spencer Steel Division of the Colorado Fuel and Iron Corporation, has ever required maintenance. This endurance test is conclusive proof that the G-E pumpless tank is an outstanding performer.

Not one cent has ever been spent for repairs on a G-E pumpless rectifier tank

Since 1948—when the first General Electric pumpless rectifier unit was installed—not a single customer anywhere in the country has paid out a penny for vacuum tank repair. And this is only a start. G-E engineers estimate a much longer life for this equipment. Here's why:

"PERMANENTLY-SEALED" TANKS, manufactured under almost antiseptic conditions, eliminate the need for a pumping system. This, in turn, eliminates such problems as mercury migration between tanks and the possibility of shutdown due to vacuum-system failure.

SUPERIOR MANUFACTURING AND TESTING methods have made this exclusive sealed-tank design possible. Tanks are assembled in a special air-conditioned room, then baked, pumped-down and sealed to assure the best possible vacuum. To check the possibility of even the most minute leak, tanks are pumped in a helium atmosphere and the exhaust is examined by a mass spectrometer leak detector capable of detecting one part of helium in 100,000 parts of normal air.

FACTORY RECONDITIONING of tanks, should it be necessary, is a relatively inexpensive process and relieves you of tank maintenance problems. The tank is reconditioned under the same controlled factory conditions described above and returned ready for more years of service. You can operate with a spare tank during reconditioning.

ADD TO THIS the highly efficient operation of mercury-arc conversion and you'll find that G-E pumpless rectifiers are the most economical way to get d-c power in the 750-kw range and above. For the whole story, contact your nearest G-E Apparatus Sales Representative or write for bulletin GEA-5689. General Electric Company, Schenectady 5, New York. 524-2

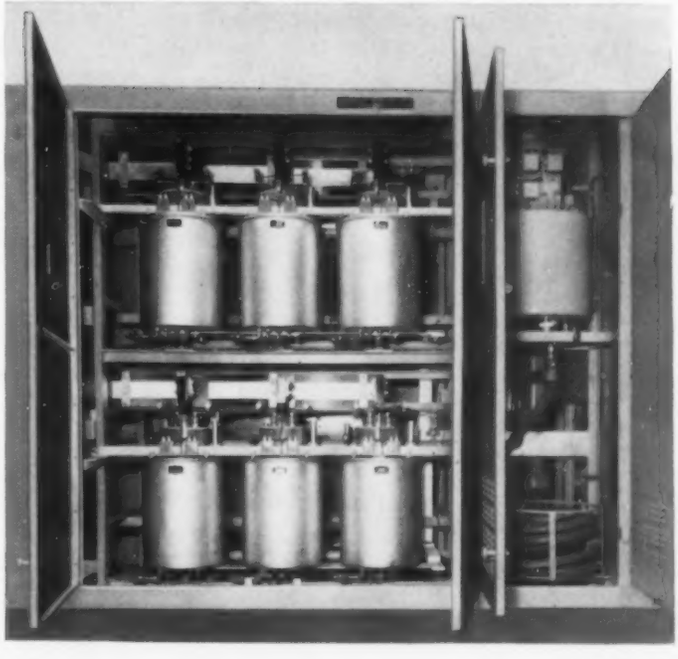
Progress Is Our Most Important Product

GENERAL ELECTRIC

19 1955

ASSEMBLY ROOM for pumpless-rectifier tanks is clean, air-conditioned to help prevent contamination. After assembly, testing with mass spectrometer leak detector assures that tanks are free from even the most minute leaks.

LONG LIFE AND LOW MAINTENANCE are the payoff when these tanks are put into service. The six-tank rectifier compartment shown here is furnished with transformer and associated a-c and d-c switchgear—a completely metal-enclosed d-c substation which requires a minimum of floor space.



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Crops *and* Shorts

THE new agreements between the United Steel Workers and the can companies is the first taste of blood for the union on the guaranteed annual wage or, as it now seems to be rechristened, supplemental unemployment benefits. These agreements provide for benefits of about 65 per cent of take-home pay (including state unemployment benefits) for a maximum of 52 weeks for any lay-off. Similar plans will doubtlessly be demanded of the steel industry next year.

Such plans will probably lead to even more contracting of certain types of work to outside companies, as well as different methods of lay-offs when lay-offs become necessary. They could work to the disadvantage of some individuals — and had they been in effect in the early thirties, some companies, would have ended in bankruptcy.

▲

THE exigencies of a situation seems to make strange bed-fellows. The union shop pact between General Motors and CIO-UAW is being contested by employees who object to being forced into the union as a requirement to holding their jobs. In a suit in Indianapolis, the union shop agreement, which would force about 17,000 General Motors workers to choose between union membership and discharge, was vigorously defended by General Motors lawyers.

▲

A classified ad in the Wall Street Journal offers a Labrador retriever pup for sale for $4000, and will toss in, free, a Thunderbird automobile, "to assure pup suitable transportation."

▲

WITH all the static generated by the various synthetic materials used in today's clothes, they're charged in more than one way.

▲

IN case you're interested, September is Better Breakfast Month. How are you doing?

▲

ACCORDING to the American Iron and Steel Institute, June shipments of finished steel products set a monthly record of 7,770,213 net tons in June.

June also saw a record payroll in the industry — $298,439,000. Wage earners averaged 40.1 hours per week at an average rate of $2.42 per hour.

▲

THE Machinery Institute estimates that the present capital investment required by U. S. business is $12,500 per worker. Therefore, if business as a whole is to absorb the annual growth in private labor force, offset the current consumption of its fixed assets, and provide for a normal growth in investment per worker, it must find each year $35,000,000,000-$40,000,000,000 in long-term capital. This must be the net realization from depreciation allowances, retained earnings, new equity flotations, and long-term borrowing.

That's a lot of money!

▲

RAPID amortization of new production facilities seems to be falling by the wayside. The steel industry's request to reopen the way for expansion continues to languish. In fact, the Office of Defense Mobilization recently closed or suspended expansion goals in many other fields. Opposition to fast write-offs stems from Treasury Secretary George Humphrey, who doesn't want to lose the tax revenue.

▲

EMPLOYMENT agencies say secretaries now do the interviewing before they take a new job. They want to know about insurance, air conditioning and single men in the office.

▲

THREE ore carriers, rated at 60,000 tons capacity each, are said to be the largest cargo vessels in the world. Built in Japan, the Ore Chief, the Ore Titan and the Ore Transport are bringing iron ore from Venezuela to the United States.

▲

A thoughtful correspondent says we needn't worry too much about foreign aggressors invading the United States. They couldn't afford to live here very long.

▲

THE Value Line investment survey makes a long range prediction on the steel industry for 1956: a production of 102,000,000 tons, sales about 4 per cent under 1955, and profits down somewhat but better than 1953.

The same source predicts sustained shipment and sales of new machinery in 1956.

▲

A survey conducted by the National Society of Professional Engineers and answered by 14,328 engineers shows median income to be about $8820. Chemical engineers run ahead with a $9730 median.

Only about half of the engineers answering earn $8500 or more, and only 10 per cent exceed $18,000 — and 47 per cent of the individuals have been in the profession 20 years or more.

Maybe this is why we haven't enough engineers.

▲

THE Atomic Energy Commission is investigating a new type of nuclear reactor that could mean lower production costs for iron and steel. It would be a "hot" reactor, and would present the problem of transferring 2000-3000 F heat out of the reactor and into the furnace.

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Metallurgical Furnace Control Systems • Boiler Combustion Control Systems • Ring Balance Flow and Pressure Instruments • Control Systems for Aeronautical and Automotive Testing Facilities

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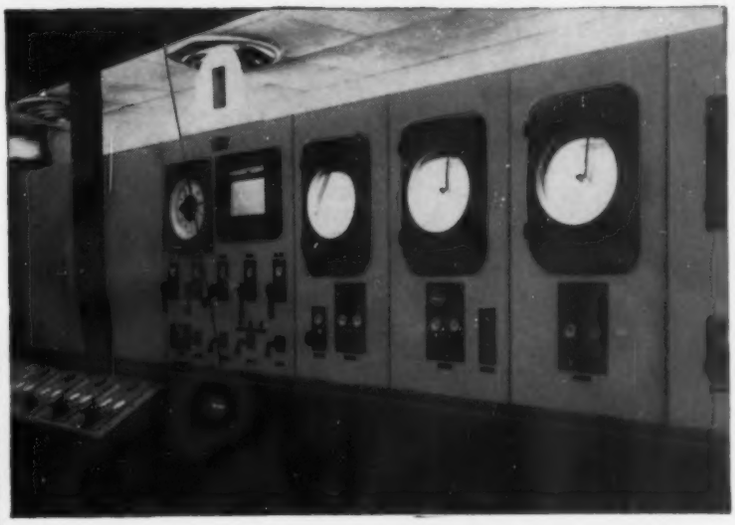
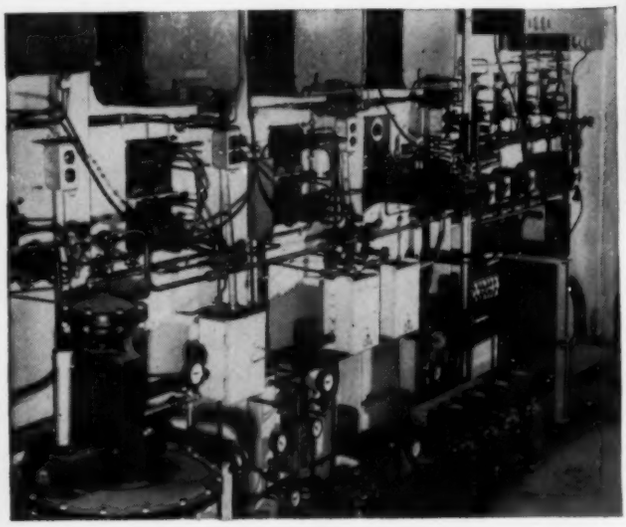


FRONT OF CONTROL PANEL

REAR OF CONTROL PANEL
Note simplicity of installation and easy access.



AND INSTRUMENTATION

for Open Hearths at INDIANA HARBOR WORKS of THE YOUNGSTOWN SHEET & TUBE COMPANY

The eight new open hearth furnaces at the Indiana Harbor Works of The Youngstown Sheet & Tube Company are equipped with Automatic Control and Instrumentation by Hagan. Fuel-air ratio, furnace pressure, and furnace reversal are controlled by Hagan equipment. The furnace reversal system includes a program controller and both maximum time and maximum temperature reversal controllers. Flow of heated gases to the waste heat boiler is also controlled.

FUEL-AIR RATIO—Regulates oil flow, air flow and atomizing steam flow in accordance with set point on control panel. Each flow is recorded.

PRESSURE CONTROLS—Furnace pressure is maintained at set point by regulation of I.D. dampers. Furnace pressure is recorded.

REVERSAL—Optimum utilization of fuel is assured by dual control of reversal. Program controller measures both elapsed time and checker temperature difference. Excess heated air is automatically bled to atmosphere.

Operators like the good housekeeping possible with Hagan pneumatic controls, and the complete accessibility of instrumentation makes it an easy job for the first helper to keep tabs on every development in the furnace.

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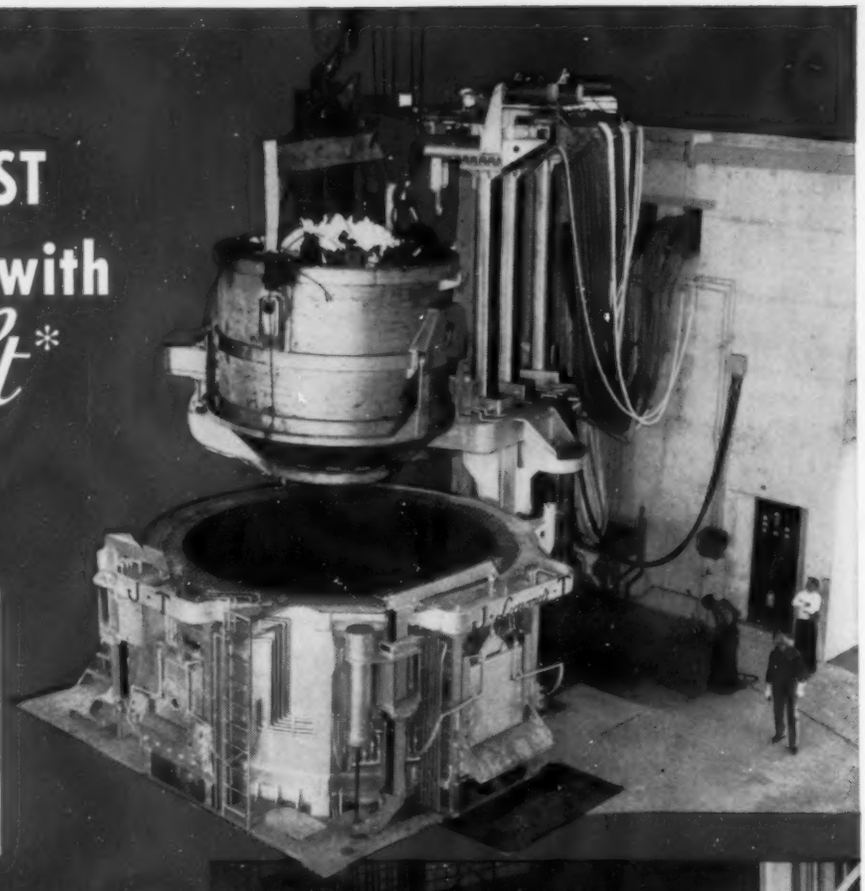

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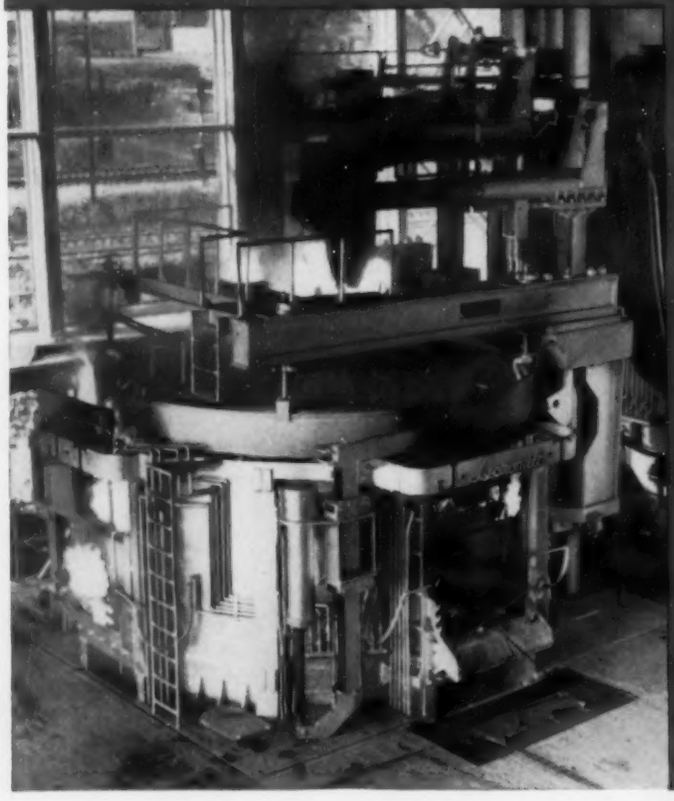

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WHEN YOU MELT... *Lectromelt*

*Reg. T. M.

Maintenance Painting in the steel industry

By CECIL SCHOFIELD
Director of Laboratories
Process and Product Development Div.
Republic Steel Corp.
Cleveland, Ohio.

. . . . of the two common methods of specifying paint, formula and performance specification, performance specification is by far the more desirable . . . . development of better paints is not handicapped, responsibility is put on the paint supplier, and a more economical paint may be obtained . . . . performance specifications, however, require a test program with means for comparing performance and for checking coating life . . . . the laboratory test program must also be keyed with field performance . . . .

▲ DESPITE the fact volumes of excellent literature have been written covering this eternally troublesome and important subject, little seems to have been accomplished towards standardization of procedures and materials to combat the ravages of the elements; especially on iron and steel.

The importance of good protective coatings for these metals can be best appreciated when it is considered that losses due to corrosion, annually approach astronomical figures.

This article is not intended to startle with new revelations, but is more or less a compilation of facts already known. These facts coupled with verifications from accelerated laboratory tests and outdoor exposure tests can be indicative of what may be expected from a given material in actual use. Therefore, the principal purpose will be to emphasize the phases most necessary to insure the best protection possible; also to serve as a guide in selecting the coating system best fitted for a given end use.

In one form or another, paint has been used throughout the ages, primarily for two purposes, decorative and protective. What is paint? Basically paint is composed of finely ground natural or artificially produced solids, known as pigment, intimately mixed or ground in a liquid called the vehicle.

The chief object of the pigment is to impart substance, opacity and color to paint. The vehicle is the medium in which the pigment is ground or dispersed and forms the adherent film that binds the pigment to the surface to be coated.

Paints are usually compounded on a roller mill, stone mill or in a ball mill. These methods insure that each particle of pigment is completely surrounded by a film of vehicle or binder. This is important to assure a uniform product, especially in high grade paints.

The rust inhibitive pigments most commonly used in steel primers are red lead, blue lead, zinc oxide, metallic zinc dust and zinc chromes.

Metal primer vehicles may be one of several or a combination of many types, especially when paints are to be formulated for a particular application.

The common oils generally used are linseed, tung (china wood), soya and perilla. Along with these are the synthetic resin type such as phenolics, alkyds, urea-formaldehydes, melamines, etc.

A combination of both of the natural and synthetic types exhibiting the characteristic slow initial set of the straight oils and the improved through drying of the resin type are generally known as resin fortified oil vehicles.

In addition to these bases of pigments and vehicles, are added many other components, such as extenders to give bulk and driers to speed the natural curing of the film.

Thinners or diluents are added primarily to reduce the body of the paint in order that more satisfactory application and flow may be obtained.

Since excessive use of these diluent media should not be tolerated, instructions furnished by the paint manufacturer for mixing, type and amount of thinner and application should be observed. These instructions

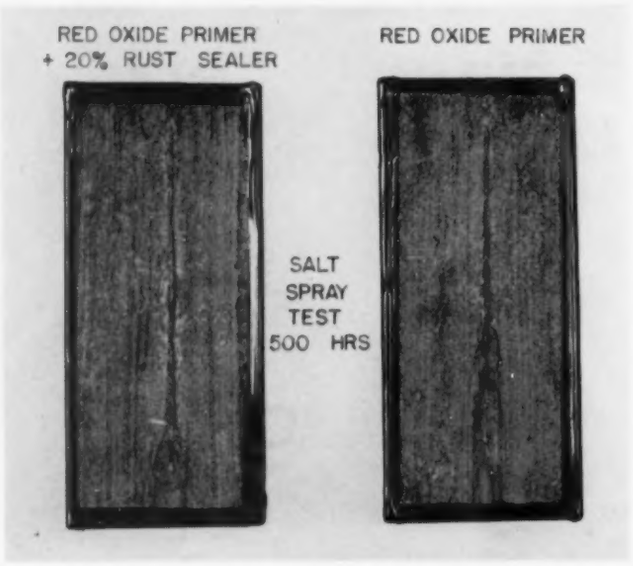


Figure 1 — View shows results of salt spray test on scratched panels.

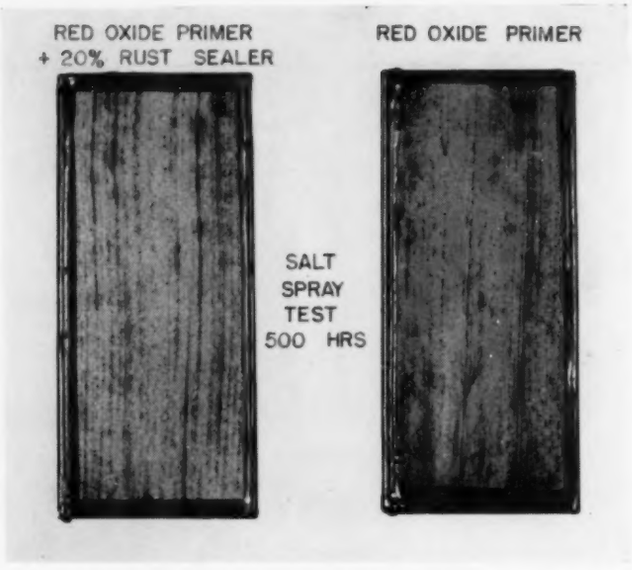


Figure 2 — View shows results of salt spray test on unscratched panels.

should appear on 5-gal containers and 55-gal drums as well as single 1-gal cans.

When a paint is formulated for a particular application such as metal primers, a definite ratio of pigment to vehicle by volume is established. This ratio is designed to impart certain film properties based on specific performance requirements. Indiscriminate additions of thinners or oils over and above recommendations of the paint supplier will upset this balance.

The net result is a reduction in solids content per gallon with a corresponding lowering of the performance expected.

To demonstrate the possible result if such a procedure is followed, two sets of panels were prepared from medium pitted rusted steel which was lightly wire brushed. One set of panels with and without a scratch, was coated only with a red oxide primer, the other with the same red oxide primer to which had been added 20 per cent by volume of a rust sealer.

These panels were then tested in a salt spray cabinet for 500 hours. Figures were prepared showing the results of this test. Figure 1 shows the scratched panels of each system. It can be observed that breakdown results indicate that no advantage was gained by the addition of the rust sealer. In fact the standard red oxide primer appeared to have a slight advantage.

Figure 2 shows the same test conducted on panels without a scratch line. Breakdown results, while comparable, show a very slight advantage in favor of the addition of the rust sealer to the paint.

Generally speaking, the iron and steel industry is faced with two maintenance paint problems. One is the coating of new work; the other repainting of existing structures already coated.

It might be appropriate to dwell briefly on recognizing the telltale signs of original coating breakdown in order to determine when repainting is necessary. Since outward appearances can be very deceiving at times, close scrutiny is often necessary to detect these warning signals. Blisters and swollen areas, even though the paint film appears to be intact, are usually definite indications of under film corrosion products. Particular attention should be given to those areas around rivet heads, bolts, edges of gusset plates, webs of channels, filler plates, etc., and most important at anchor plates and anchor bolts of tower structures and building columns.

The writer, after probing through the outer coating on sections of a structural member, which appeared, at a casual glance to be perfectly sound, has observed many instances in which all that remained was two coats of paint and one coat of rust.

Unfortunately, it is not yet possible to obtain a single paint coating that would be economical to use price wise and possess all of the desired qualities required for the ideal coating. Consequently, it is necessary to set up a paint system including a primer, intermediate coat and finish coat or coats. Each coat of paint has a specific function to perform, and each coat is dependent on and supplements the other, which is as it should be if any measure of success is to be expected from the system.

However, of greater importance than the coating or coatings to be applied is the preparation of the base metal to receive the first and most important coat, namely the primer.

The best paint available, even though expertly applied, cannot overcome the handicap of a poorly prepared surface. Proper surface preparation is vital to a successful paint job.

Before attempting to paint new structural work, all rust, grease, loose scale and other contaminents must be removed. This can be accomplished by sandblasting, flame cleaning, wire brushing or other mechanical means.

An inhibited acid type wash treatment can be used in areas inaccessible for any of the mechanical methods.

Several of these acid products which are available on the open market have proven very successful in dissolving the iron oxide or rust without any appreciable attack on the base metal. After the acid treatment is complete, there should follow a water rinse to remove all loose particles and any excess acid that may be present. Upon drying, the surface so treated is in excellent condition to receive the first coat of paint.

As is the case in all metal treatments, the instructions

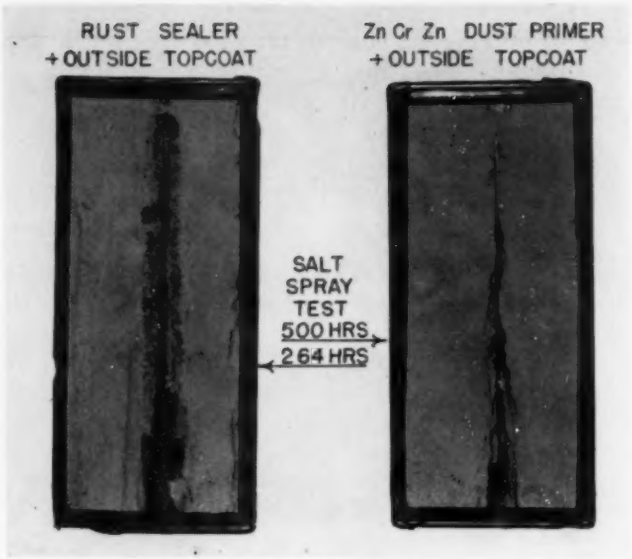


Figure 3 — Scratched panel with rust sealer and outside top coat broke down in much less time than the panel with a chromated zinc dust.

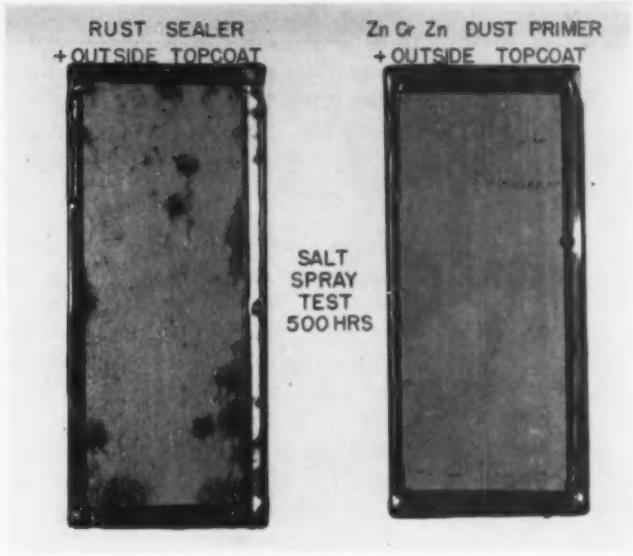


Figure 4 — Test on unscratched panels similar to those of Figure 3 showed breakdown on the one using rust sealer.

of the manufacturer should be adhered to if a satisfactory result is to be obtained.

In many cases, on new structural steel, there are isolated areas of tightly adherent mill scale very difficult to remove. A paint system applied to those areas of steel where this scale condition exists, may, after a few years exposure show breaks in the paint film. This is due to the tendency of the scale to pop or erode when exposed to the atmosphere.

These breaks should be cleaned and spot repainted. An alternate method suggested to overcome this problem of tight scale removal before painting is to allow the surface of new structural steel to weather sufficiently to obtain complete removal through rusting and erosion. Approximately six months has been recommended as necessary for complete removal of the scale.

Upon completion of this cycle, the metal should then be prepared in the same manner as outlined for new structural work.

When repainting existing structures all loosely adhering paint must be removed. Blisters should be broken and underlying rust thoroughly removed. Corroded areas should then be treated with an acid wash as outlined in the procedure for new structural work. Spot priming at these locations is the next step before repainting the entire structure.

In recent years, much promotional work has been done advocating the use of "wetting oils" as a metal treatment for use over rusted surfaces. Such materials notably the fish oils, raw or boiled linseed and combinations of drying oils have been used as surface preparations where complete removal of surface corrosion products by standard methods has been impractical. These products are not classed as paints in the strict sense of the word. Neither do they function in the same manner.

The success of "wetting oils" as manufactured today is due to their low surface tension, extremely good wetting properties and the ability to penetrate into the pores of the rust.

Primarily, these materials act as sealers, binding the rust particles together with a protective oil coating to the exclusion of natural corrosive elements, such as moisture and the reaction products which are already present on the metal surface. This protection will exist only as long as the film remains intact.

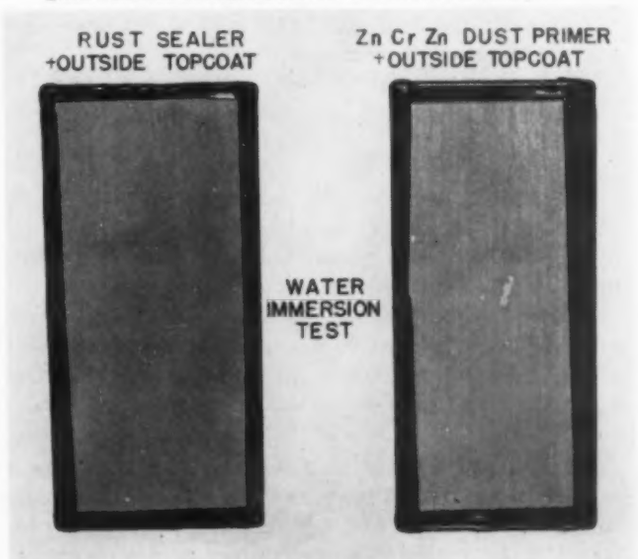
Extravagant claims which have not been proven in laboratory tests or actual practice have been made for many of these products.

As we are all too prone to take the easy way out, such statements as, "Don't bother to remove the rust, just put our material over it," causes one to hope "This is it, the answer to all of our corrosion problems."

Statements like this often can be misleading and, while lulling one to sleep through a false sense of security, may lead directly to disastrous results, these from another angle, namely "*safety*."

As engineers, we are well aware of the fact that all buildings, tower structures and structural supporting members are designed to carry and withstand definite loads. Accordingly, columns, beams and angles of definite size and thickness are specified for these loads.

Figure 5 — Water immersion test on unscratched panels gave results comparable to the salt spray test.



When corrosion attacks the members, the inevitable decrease in wall thickness results in a corresponding decrease in the load carrying capacity of the structures.

Although recognizing the fact that wetting oils or rust sealers do have their place in metal protection, it is the writer's belief that all heavy deposits of rust should be removed to the base metal regardless of the treatment to follow.

Common logic dictates that any appreciable thickness of rust, even though coated with an oil or paint, will never replace the actual metal that has been lost due to corrosion. Therefore, in order to maintain the designated safety factor when the above conditions are apparent, it would be safer to replace the corroded section than cover it over.

It should be remembered that metal treated with a rust sealer, should be coated with the usual primer and top coats of paint for utmost protection.

To determine the relative values of a rusted surface treated with a wetting oil type of coating versus an inhibited type of primer, test panels were prepared in the laboratory in the following manner:

Six panels with medium pitted rust were cut from one dry sheet of steel. All loose particles were removed by lightly wire brushing the surface. Three of the panels were then brush coated with a known rust sealer and the remaining three with a zinc chromated, zinc dust primer.

After a drying period of 24 hours, a top coat of an exterior type gray paint was applied by brush. Panels were then allowed to age for seven days before testing.

Two of each, with and without a scratch mark, were then placed in a standard ASTM salt spray cabinet and two of each without a scratch in distilled water immersion at 95 F plus or minus 2 F.

All samples were observed daily, and removed when visible breakdown occurred. Figure 3 shows the results of these tests.

Note that the salt spray tests of the scratched panels show considerable differences in the protective properties of the various systems. For example, the steel with the rust sealer and top coat, at the end of 264 hours gave evidence of complete breakdown at the scratched area, with creepage extending to one-quarter of an inch on either side of the scratch and base metal being exposed.

Under similar test, the steel coated with the chromated zinc dust primer and top coat, exhibits, at the end of 500 hours, practically no creepage from the scratch or exposure of base metal. Figure 4 illustrates two panels without a scratch line and exposed to salt spray for 500 hours.

Here again note that the panel coated with the rust sealer shows areas of complete breakdown, while the other panel with the chromated zinc dust primer shows only scattered pin point rusting.

Figure 5 illustrates two panels without scratch lines after being subjected to a complete water immersion test at 95 F plus or minus 2 F in distilled water. Once more the results follow the same general pattern as in the previous tests.

The panel coated with the rust sealer has approximately 75 per cent of the area covered with light surface rust at the end of 72 hours in test. In contrast the panel with the chromated zinc dust primer, after 500 hours in test, shows no evidence of any surface rust whatsoever.

This information is given for what it is worth principally to point out that we are still a long way from a panacea for all of our corrosion problems.

The discourse so far has dealt with preparation of hot rolled materials. A few words about hot dipped galvanized metal and preparation might not be amiss at this time.

The general surface condition of newly galvanized metal is oily and slick. This condition must be corrected before any paint is applied, if we are to expect any degree of adhesion of paint to metal.

Probably the surest method is to expose the galvanized metal to the atmosphere approximately six months. The natural elements will then have changed the character of the original surface and formed an oxide which should be brushed to remove all loose particles. This will provide a better base for the prime coating.

Proprietory solutions and mildly acidic formulas have also been recommended as a surface treatment for hot dipped galvanized finishes.

However, not too many of these treatments have proved successful and should be used only when it is not possible to take advantage of the natural oxidation of the surface. In either case, a special primer is required for use over galvanizing regardless of the subsequent top coats to be applied.

Touching briefly on the mechanics of application, most maintenance paints are applied by brushing or spraying. If the brush method is used, the paint can usually be applied at the viscosity at which it comes from the paint manufacturer. However, the paint for spray application must be much less viscous necessitating the addition of a solvent. Information on the type and proportion of solvent to be added to the paint should be obtained from the supplier of the particular coating being used. The correct air pressure and fluid flow are absolutely necessary in spraying if a satisfactory result is to be obtained.

For example, too much air pressure and not enough paint flowing through the gun will give a dry spray which will lack good adhesion and have very poor wearing qualities.

If, on the other hand, there is not enough air pressure and too much paint flowing through the gun, there is an adverse condition. In this case, a very heavy film of paint would be deposited in a relatively small area which would be conducive to runs and sags as well as reducing the amount of coverage expected per gallon of paint.

Temperatures and weather conditions are extremely important when painting outdoor structures. If the temperature should be below 50 F or if there has been heavy rain or wet spell, painting of exterior surfaces should be deferred until conditions are more favorable. It is logical to believe that if paint is applied when these adverse conditions exist, the result will be a probable breakdown of film performance, a decided lack of adhesion and a contributing factor towards under film corrosion.

Paint failures can also occur even though weather conditions were favorable at the time of application. Some of these are natural causes such as moisture, in the form of rain, fog, humidity and sunshine.

Other factors are fumes, smoke and vapors always prevalent in the atmosphere in any industrial area.

A very common cause is poor preparation of the base metal before priming, or the use of the wrong type of primer as a base coat.

Failure on a repaint job can most likely be traced to incompatibility of the new paint to that previously applied, or failure to remove dust, dirt, grime or chemical film on the surface of the original paint.

Indications of probable paint failure from corrosion products under the paint film will show up as blistering, peeling or scaling.

Visual appearance of a poor quality paint can be recognized in such forms as alligatoring, wrinkling, crawling, checking or excessive chalking.

To obtain a good paint system with excellent weathering properties, it should be remembered that the tighter the prime coat of paint adheres to the base metal, the more durable the final finish will be.

The most important aspect of coatings and metal preparation have been briefly covered, and now the controversial subject: "On what basis should paint be procured."

Two ways are open, one is on formula specification, the other on performance specification. Let us deal first with the formula specification and determine what advantages or disadvantages this procedure has to offer.

In order to do a successful job of formulating paint, it would be necessary to establish a department with this one purpose in mind. A staff of highly trained paint technologists and formulators would be necessary to maintain such a department at a properly functioning level.

In addition to the staff, all vital equipment apparatus and instruments to conduct the necessary research and development in formulating would be required.

A formula specification naturally relieves the paint supplier of all responsibility for any breakdown in performance of the product as long as he has furnished that which was specified. In addition, by following this method, a definite restriction is imposed. For example, a specific formula at a fixed price per gallon, may sometimes cost more and be inferior to a product already standardized and on the market.

The rapid strides which paint technology is making today on protective coatings for metals, should bring out the tremendous advantage to be gained simply by taking advantage of the knowledge and talent available.

About the only advantage, formula specification offers lies in the fact that the establishment of definite percentages of pigments, inert materials and vehicle, force the paint supplier to strictly adhere to the formula acceptable to the customer.

However, the net result is that the initiative has been taken away from the paint manufacturer, and he now becomes a paint mixer with little or no chance to use his ingenuity to improve the product.

Now let us weigh the merits of purchasing on a performance specification. One advantage of this method is that the supplier of the coating is given something definite toward which he can work, thus eliminating a lot of guesswork. Consequently, the number of samples submitted for approval will be smaller than if this information was withheld. The responsibility for obtaining the best product possible for the job has been placed where it belongs, and if a paint failure occurs, the supplier of the paint can be held accountable if all conditions remain as specified.

The door is left open to new materials as they are developed. Some of these new products may be as good as, and yet cheaper than a specific formula. The result is a benefit to the buyer without any loss in performance requirement.

When procuring paint in this manner, another phase presents itself, that is, the functioning of the purchasing department.

In our organization, all buyers or purchasing agents are furnished with copies of performance specifications for each specific application by the laboratory. They in turn furnish the vendors with copies of these specifications. When paint samples are ready, they are submitted to the buyer, who in turn requests the laboratory to conduct tests against the specifications.

When the test is completed, the laboratory result is sent to the buyer, who then, advises the vendor of the results.

You are probably wondering how a performance specification is developed for a particular condition. Basically, the essential conditions the coating should withstand must be known.

Common reasoning suggests that one specification alone will not cover all of the requirements and still be economical from a cost viewpoint. Since there is nothing complicated or mysterious about setting a performance specification, a few typical examples of the procedure involved in determining the number of specifications required and of the value which must be assigned to each of the procedure involved, will be cited.

Supposing a request is made for the recommendation of a coating to be used in and around a pickle room, what are the basic factors involved?

Moisture, acid vapor, fumes and high humidity are factors. Knowing that without moisture present, the film breakdown would be negligible, the water or moisture resistance of the coating must be emphasized first, since acid is the next contributing factor in all stages of the pickling process, acid resistance is second in importance.

Consequently, the accelerated test specification would read "the coating must withstand a certain number of hours without breakdown in water immersion, humidity, acid fumes and vapors."

Another example would be for paints over outside structures where there is no influence of acid vapors or fumes. In this case, the following tests would be specified, water immersion, humidity, abrasion, weatherometer and salt spray rated in that order.

For paints used to coat the interiors of the average mill building, humidity, abrasion and salt spray tests would be indicated.

Stack paints should be evaluated on the basis of water spray and heat resistance. Paint for galvanized roofing or siding sheets would be tested for water immersion, weatherometer, and salt spray.

This will give a general idea of the mechanics involved in composing a performance specification and how invaluable this information can be to the paint manufacturer who cannot always be familiar with the conditions that actually exist.

This presents the leading question, "How can one be

certain of obtaining the right coating materials for a specific application?"

For this information, the past history in the paint industry is consulted. Certain types of materials have proven over the years to have excellent protective qualities for particular usage. As a result, it is fairly safe to conclude that such materials are a good place to start. For instance, referring back to the specification for a pickle room area, there is a choice of at least three paint systems satisfactory for this application: asphaltic materials and paints, chlorinated rubber paints or the newer types of plastic paints. The base cost of the products as well as the protection afforded, rises in the same order. Therefore, it is necessary to determine whether or not the type of protection desired justifies the expenditure involved. The base metal preparation and how well this operation can be accomplished are also contributing factors in making this decision. When all these pertinent points are resolved, a definite suggestion can be made.

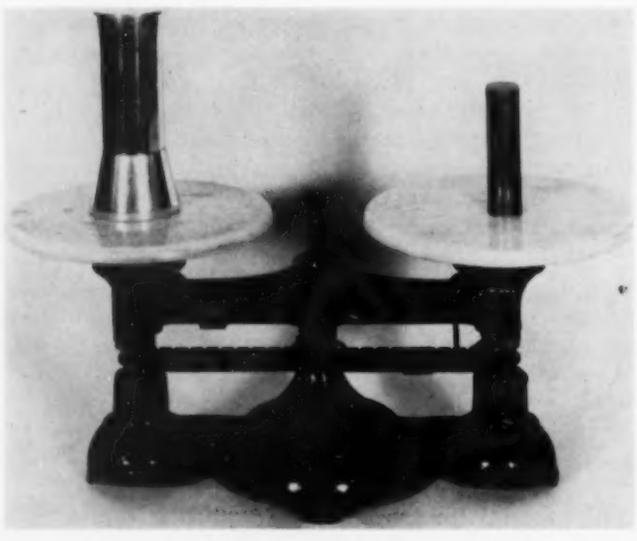
For outdoor structures, newly erected and in normal atmospheres, at least a three-coat system should be advocated; an inhibitive primer, an intermediate sealer coat such as a graphite type paint, and a compatible top coat which will meet the specification requirements.

Stack paints which as a rule do not require a primer can be of the bituminous type, heat conversion type or heat fusion type, all dependent on the temperatures involved and the result desired.

Paints for use around a coke plant area, due to the particular atmospheric conditions prevalent, can be a combination of several types depending on the structures to be coated. Some such materials are asphaltic paints, bituminous or tar paints, acid and fume resisting paints with an inhibitive primer, all of which can be used with a large amount of success in this location.

For priming galvanized or zinc coated steel, one has the choice of using any of the various zinc chromate type so-called wash primers. These coatings are usually applied to give a film thickness of three-tenths to five-tenths of a mil and air dry in approximately 10 minutes. Straight zinc dust primers have been giving excellent results for years when applied to galvanized metal and are still being recommended for this purpose.

Figure 6 — A weight per gallon cup is essential for the control laboratory.



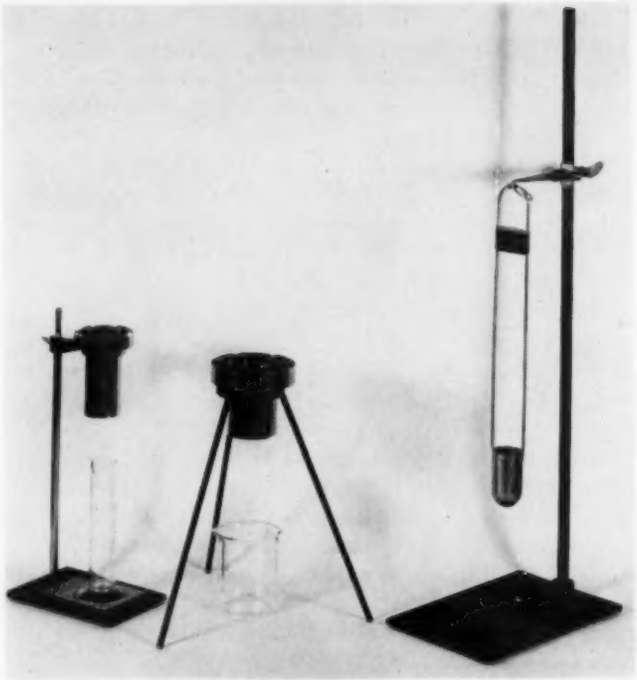


Figure 7 — Three types of viscosity cups are used.

However, based on laboratory tests as well as field experience, it is the writer's belief that the addition of zinc chromate to the standard zinc dust formula has shown a definite improvement in performance as a galvanized metal primer.

It is very possible that variations in this zinc chromate zinc dust formula can be made to reduce cost and establish its use as a general primer formula for uncoated as well as galvanized steel or iron. Laboratory tests are being conducted towards this end at the present time.

In recent years, many of the major paint manufacturers have established technical service departments, for the express purpose of analyzing coating problems and making sound logical recommendations to customers.

However, before any intelligent solution to the problems can be offered by the trained specialists of these technical service departments, one must first know what he wants to achieve.

With full cooperation on both sides, there can be no question as to an end result beneficial to both parties involved.

Better coatings at a reasonable cost will only be obtained if the ingenuity of the paint and coatings industry is challenged. Past experience has in many instances proven this to be a fact.

Improvements in any field are not necessarily due to following a hard and fast rule, but usually come about by deviating from the standard path into side roads where the set rules do not apply.

Theoretically, the bumble bee cannot fly. The body is entirely out of proportion to the wing spread. However, the bumble bee does not know this, so he keeps right on flying. By the same token, it is not desirable to close the door on any future improvements in the coating field; hence the use of a performance specification which can be changed to higher demands as better products are developed, should certainly have a greater all around advantage, than a fixed formula specification.

Before passing to another subject, the writer would like to offer one suggestion for serious consideration. It is this, if all structures and buildings were correctly prepared and adequately protected from the ground, up to five or ten feet above the ground, a decided decrease in coating failures and corrosion development would be the ultimate result, a result well worth the extra effort.

Assuming that a coating for a specific application has been decided upon as a standard, the paint supplier should furnish the customer with an analysis of the proposed product. This information should show:

1. Weight per gallon.
2. Pigment per cent.
3. Vehicle per cent.
4. Total solids, per cent.
5. Manufacturer's tolerance, per cent.

Included as a guide should be given the basic pigments used, but not necessarily the actual percentages of each pigment. The type of vehicle should be definitely stated.

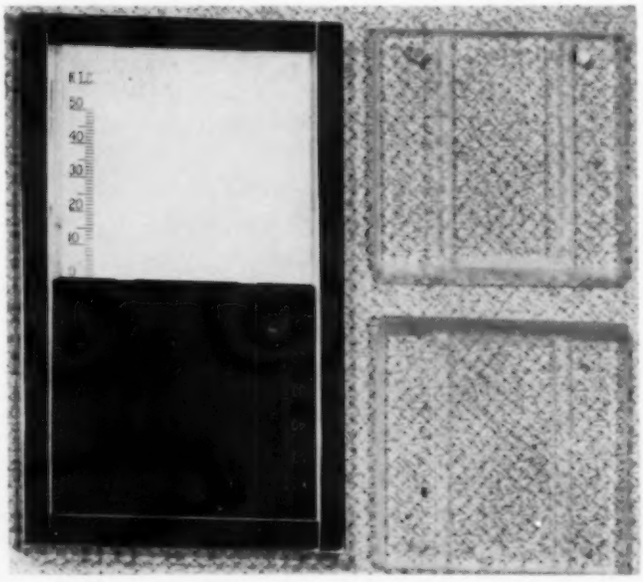
It is now apparent that some method of batch control should be installed to insure uniformity of future shipments of coating materials.

A material control laboratory to do this work successfully will require the following apparatus, all of which is standard in the paint industry:

1. Weight per gallon cup.
2. Centrifuge to determine pigment and vehicle percentages.
3. Viscosity cups.
4. Hiding power charts.
5. Scales for weighing.
6. Miscellaneous beakers, spatulas and sampling cans, etc.

As a means of identification, some of this apparatus is shown in the following figures. Figure 6 identifies the weight per gallon cup, scales and counterweight. Figure 7 illustrates three types of viscosity cups. The ASTM, Ford, and the Zahn. The choice between these types is a matter of personal preference. Figures 8 and 9 illustrate methods of determining the hiding power of the paint. First, by the use of a Pfund cryptometer, and secondly by means of Morest hiding power charts.

Figure 8 — The cryptometer is one means of determining covering power of paint.



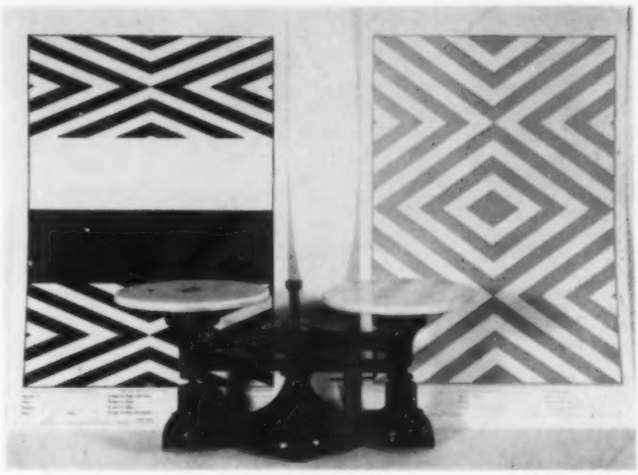


Figure 9 — Hiding power charts are used in another method of determining the covering power of paint.

The degree of accuracy and application is the significant difference between these two methods.

The number of men required to staff a control laboratory is dependent largely on the volume of paint involved. Highly trained specialists are not a requisite for this type of control work. Alert technicians with some paint chemistry knowledge or training and the ability to make common sense interpretations of recorded data are the main requirements. It is the responsibility of this laboratory to contact the paint supplier if marked deviation from the original analysis is observed. The foregoing information is based on the minimum investment required to accomplish an end result, an end result that should in a short time overshadow the initial cost of establishing such a department.

In order to keep abreast of the times in the coating industry, and to take advantage of new developments in this field, an addition to the control laboratory should be considered. This addition would be a performance evaluation test laboratory, the function of which would be the testing of new coatings against those already in use as well as the evaluation of present coatings when establishing performance specifications.

The initial expenditure for the apparatus and equipment for a department of this nature would be considerably in excess of the outlay for the control laboratory.

Minimum equipment requirements for an evaluation laboratory would be as follows:

1. Weatherometer.
2. Water immersion tank.
3. Salt spray tank.
4. Humidity cabinet.
5. Outdoor exposure rack.
6. Impact tester.
7. Dry film thickness gage.
8. Glossmeter.

Figure 10 illustrates the weatherometer. This machine is primarily used to determine fading, chalking, crazing, alligatoring and loss of gloss of the coating under test.

Figure 11 illustrates a water immersion tank containing glass jars filled with distilled water in which duplicate test samples are placed, the temperature

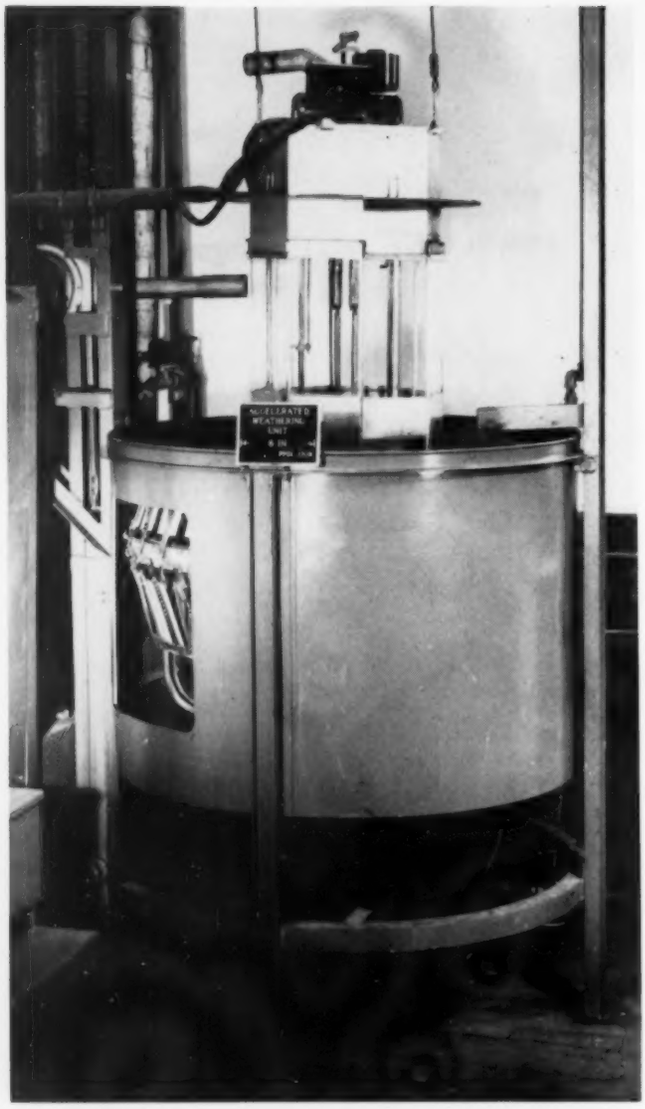


Figure 10 — The accelerated weather unit determines fading, chalking, crazing and loss of gloss.

being maintained at 95 F plus or minus 2 F. This apparatus is used principally as a quick breakdown test for checking permeability of coating films and evaluating the moisture resistance of a complete paint system. This is of particular importance in the area where water may be trapped on a structure or building and remain for some time.

Figures 12 and 13 show a standard ASTM design salt spray tank, using a 20 per cent salt solution and maintained at 95 F plus or minus 2 F. This equipment is universally used to obtain a relatively quick overall breakdown of a coating and is of particular importance when structures are located in salt water coastal areas.

As there is no standard yet established for the design of a humidity cabinet, it is a matter of personal choice in purchasing any one of several listed on the market today.

The object of this test is also one of determining film permeability under controlled temperature and constant known humidity. Usually this unit is operated at approximately 100 per cent relative humidity. The formation of fine blistering of the paint is the usual indication of film failure in this test.

For long term observations under actual outdoor weather conditions, use is made of the exposure rack on which duplicate panels are placed and coating breakdown recorded at regular intervals. At the first signs of coating failure, results are compared with those obtained in the laboratory based on the accelerated test and an attempt is made to correlate months or years of outdoor exposure against hours in laboratory testing. Surprising as it may seem, the salt spray test has shown the best correlation of results for normal outdoor exposure when no other deteriorating influence is present.

The vagaries in laboratory accelerated testing are well known. All of this testing equipment is used entirely to evaluate on a comparative basis the differences in performance of various coating systems.

The performance of present coating systems can be determined for any specific application and the results used as a criterion for evaluating new coatings recommended as being superior to the system already in use. It is reasonable to believe that if the present coating withstands a definite number of hours in accelerated tests and a new coating, when tested under the same conditions, shows an increase in resistance to breakdown of 25 to 50 per cent in time, that a definite increase in actual service life can be expected. The proportion of increase will not be in the same ratio as the accelerated test, it may be either more or less. However, any significant increase in the life of any protective coating means a lower maintenance cost and longer periods between recoating. This saving can be very substantial.

An evaluating laboratory of this kind is the logical place to test any proposed paint system. Immeasurable time can be saved, inferior coatings eliminated, costly tryouts cut to a minimum and better coatings the outcome if this is done.

Today, many paint companies, with the aforementioned testing equipment, are prepared to furnish as a guidepost test results giving the number of hours to breakdown of a particular paint or paint system.

If such a program of testing is warranted and decided upon, a word of caution at this time in preparing test specimens will not be amiss. The type of steel to be used as test panels should correspond to the actual structure to be painted: for instance, the use of flat hot rolled steel panels for all structural steel work, flat galvanized panels for all galvanized work and so forth.

Figure 11 — The water immersion tank is used as a quick breakdown test for checking permeability of coating films.

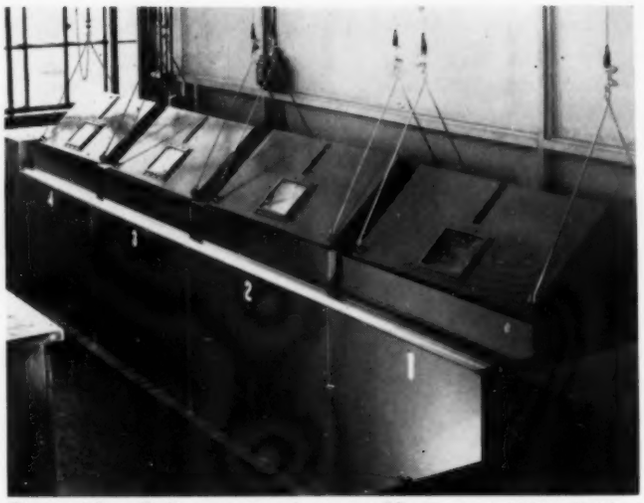


Figure 12 — Salt spray tank uses a 20 per cent salt solution held at 95 F plus or minus 2 degrees.

All test panels should be in duplicate at least. They should be cleaned, and the coating applied in the same manner in which it will be applied in the field; in past experience the type and condition of the metal surface has had a very definite bearing on the final results.

From what has been said, it would seem that the whole problem, which is, in general, one of bringing order out of confusion, revolves about two important factors: first the necessity of standardization of paint methods in the iron and steel industry, and of equal importance, the standardization of paint procedures and products in the paint industry.

Establishment of such standardization has been needed for some time. With cooperation, an effective program could be established to the benefit of all parties concerned in both industries.

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DISCUSSION

PRESENTED BY

B. W. ALCORN, Secretary, Tousey Varnish Co., Chicago, Ill.

N. T. BEYNON, The Sherwin-Williams Co., Cleveland, Ohio.

E. W. WEITH, Glidden Co., Cleveland, Ohio.

B. W. Alcorn: I believe strongly that the author is taking a long overdue stand in favor of performance specifications and would like to support him from the side of the vendor. I will confine my comments to placing emphasis on the performance specification from the seller's point of view. There are four main steps in the procedure under which we like to operate, as follows:

1. We are given the requirements for the product, and some idea of the price range is indicated.

Mr. Schofield has covered the spelling out of use condition, so I will concentrate on the price range.

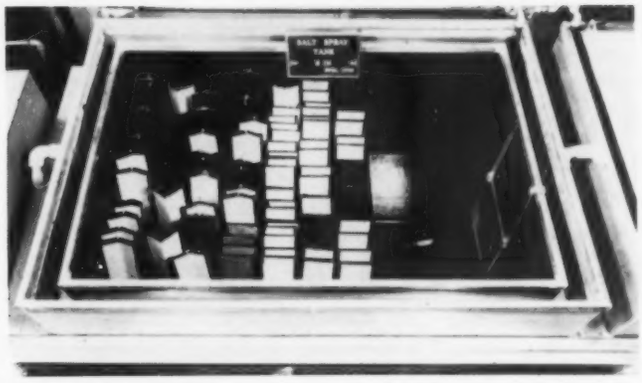


Figure 13 — Test panels are shown in salt spray tank.

Paint can be formulated for ultimate performance with price no object, or against a price factor as well as performance. What is the use of wasting time producing a better product if the resultant price is too high and the additional quality is not needed? Time can be saved for both vendor and purchaser if the general area of price expected is discussed. Paint competition being what it is, the vendor will still quote his lowest price on the material submitted in order to stay ahead of his competitors.

As an example of this type of case, for a heat resistant finish, $25 silicone enamels are probably unnecessary although they have the best heat resistance. The heat requirement may not be high enough to justify such an expense.

2. We bring the purchaser preliminary displays and information on the product we intend to submit.

The purpose of this procedure is to convince the purchaser that it is worth his time to test our samples and, at the same time, get his opinion as to the quality of our results. If he does not feel that our exhibits and data are of sufficient interest, we will reformulate to show an improvement before submitting samples.

3. Samples are submitted and a complete laboratory test is run by the purchaser.

This is our insurance policy, as well as evidence of our quality. Once the purchaser, on the basis of his tests against the requirements, approves our product, it establishes a standard. As long as any future shipment of the product show the same test results, a field failure could be charged to its real cause.

Mr. Schofield pointed out that many failures are due to surface preparation, poor application, etc. The establishment of test standards will enable the blame to be placed where it belongs — on the paint, if justified; if not, where it actually belongs.

4. A quart sample of each shipment is sent to the control laboratory.

This is more necessary in the case of companies with multi-plant operation, but a good system to follow for any quantity purchaser.

The handling of these samples is up to the individual laboratory. Each sample may be tested as received, or one out of three or five, or they may be filed without testing for future reference in the event of trouble. They are available, however, to be checked at any time — to prove or disprove a complaint on paint.

I would like to emphasize that what I have outlined is standard procedure in selling to production line paint users and is practiced by practically all of our com-

petitors in that field. If you were to call on the Ford Motor Co., or Frigidaire, or Truscon Division of Republic, or Allis-Chalmers, or Caterpillar Tractor or any other major users of finishes, the aforementioned procedure would be followed. You would get a performance specification, a general idea of price, and the name of the man to whom you should submit exhibits and data. The other steps would follow.

If the largest users of high grade finishes all follow this program, why should not maintenance finishes be purchased on the same basis?

In conclusion, let me again point out the obvious. You are better served by stimulating paint research and improvement by spelling out requirements than by attempting to standardize formulas. The easiest thing for us to do is manufacture to a formula. Whether our interpretation is successful is another matter, but as long as we can certify to the proper ingredients we can not be blamed.

Try, instead, to give us the facts on your requirements and allow us to give you the material to do the job.

N. T. Beynon: I would like to enlarge on one or two points that Mr. Schofield has covered so ably. Standardization is a good word that a lot of people like to use. However, it may be carried to the point where everything and everybody would be alike. It has its merits, but standardization can only be carried out where it is based on full information.

I like to think of the person who has paint in his garage at home, and it is house paint. He paints his garden furniture with it, and then all of his guests stick to the seats of the chairs. That is "standardization" to a high degree — but it was not based on full information. He should have used a furniture enamel for the garden furniture.

It is good to standardize, but you should base it on full information by exposures in the various areas. You have problems at different points which may be standardized, to your way of thinking, or you may think it is nice to use just one product. "This is the one that solves all my problems. I need no longer worry about it."

With that enlargement I would like to go to another item on which I would like to make a comment. As time goes on, the price of labor has increased much more in proportion to the cost of the product — it might be that people should take a look at products. It may be that they are getting a better buy and saving money by buying a higher priced product. Essentially, what that means is this: If you have been operating and thinking, "Well, I am going to buy the lower priced material," maybe that is not always true. It may be that you can save money by paying 25 to 50 per cent more to get something which does your job.

In years gone by that might not have been so true but it is true now wherein, usually, a five-gallon can of paint costs you close to $100 to get it on the surface.

E. W. Weith: The function of surface preparation, although quite often minimized, is directly proportional to the durability of the finish. Practically all paint films are permeable to a slight degree. The water solubility of salts or contaminents underneath the paint film which does not allow the permeability of the water to progress at an even rate into the film and out of the film will cause failures in the form of blistering, scaling, cracking, loss of film continuity, and, therefore, loss of protection.

Paint films are slightly on the acid side and, consequently, the surface you are putting the paint film on has to be prepared. Above and beyond specific formulation, the continuity of a paint film is probably the most important thing after your surface preparation. Continuity of paint film can be maintained and assured if a multiple coat system is followed — similar to that employed in the painting of tanks, boats and bridges.

Applying primers, sealers and top coats of dissimilar color to complete hiding assures the operator of applying the minimum film thickness required for optimum performance.

A paint film in its liquid state is slightly hydroscopic and consequently, the removal of the solvent immediately after the application of the paint film is necessary to minimize this tendency to absorb water into the paint film. This can be insured if painting conditions are carried on under conditions of normal temperatures, above 50 F, and with adequate air circulation. If the solvent remains in the paint film, it will take on water and there will no longer be the continuous mass originally thought applied.

In looking at the value of a paint film, the performance durability versus cost must be considered. By testing a standard formulation, the variables are reduced so that one can evaluate the film in this manner.

Evaluation tests in the laboratory are not necessarily indicative of field performance. But, over a period of years there is a history built up correlating accelerated tests with field performance.

Mr. Schofield has covered in considerable detail the importance of determining corrosion by means of water immersion, humidity cabinets, salt spray cabinets, accelerating testing units, etc. However, even if we were asked to meet a specification, the variations in durability and performance in a standard formula are not always reproducible, because in a standard given formula, the method of compounding has a very definite effect upon durability, and a definite effect upon performance.

If a test program is contemplated, it might be well to request that the paint supplier give supporting data or evidence of data of field performance versus accelerated testing. Once a program is established, it might be well for the end user to run his own field test program in conjunction with the supplier's accelerated testing program.

In establishing the minimum results for any type of coating, it is well to keep in mind to establish optimum performance in all properties required.

Now to touch lightly upon the discussion on wash primers, Mr. Schofield mentioned that wash primers (zinc chromate type) are not primers in the sense of the conventional red lead or oxide-type materials. Since zinc chromate is slightly water soluble, it forms chromic acid and reacts with the base material, thereby acting as a surface preparation.

Concurring with the thoughts of the two previous gentlemen; given a testing performance specification, given the end use, given the requirements, we feel quite sure that the paint industry would be very receptive to a continuing program of test correlation such as is being employed in the industrial and maintenance coating fields.

BY ABNER H. BAGENSTOSE, JR., Eastern Regional Manager*, Insul-Mastic Corp. of America, Pittsburgh, Pa.

Use of Heavy Cutback Asphaltum Mastic Coatings in Coke Plant Areas

. . . . mastic materials can supplement paint to protect materials in bad corrosive areas . . . . necessary for success are proper material selection, proper surface preparation and proper application . . . .

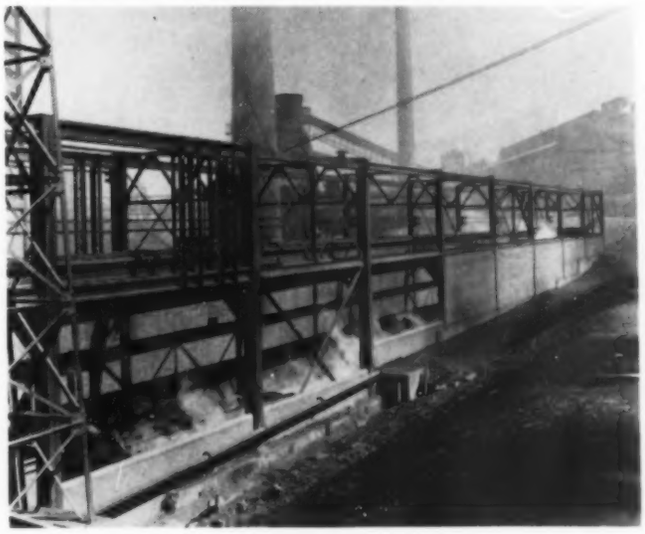
▲ THE use of heavy asphaltum mastic coatings as a protective coating for metal, a weather and vapor barrier for thermal insulation, and a waterproofing for masonry buildings in coke plants is increasing every day. The intent of this article is to describe this type of coating in general, point out its uses, and to discuss the three primary conditions necessary to obtain a good protective coating job over steel.

In general, black asphaltum mastic coatings are blends of petroleum asphalts that are cutback with petroleum naphthas plasticized with natural asphaltums and oils, and reinforced with mineral fillers. Since there are many different varieties of the above basic ingredients making possible countless different formulas, the finished products on the market today vary in physical properties and performance. These coatings are formulated to be spray applied to a heavy thickness of 1/16 to 1/8 in. in one application.

Acids and alkalies emanating from coal, coke and coke by-products in coke plants combined with moisture and air create severe corrosive conditions for steel and masonry. This corrosion can be controlled if the surface of steel and masonry is isolated from corrosive agents by heavy durable, acid and alkali resistant, organic coatings. Ordinary paint systems have a relative short life in heavy chemical atmospheres, while, on the other hand, mastic coatings have demonstrated their ability to outlast conventional paint systems many times over in the same atmosphere. Although there are many reasons for paint failure, the chief reason is low film thickness which averages 3½ mils for a three-coat system. Mr. R. R. Pierce, corrosion engineer for Pennsylvania Salt Manufacturing Co., states in an article, "Why Go To Thick Protective Coatings?" published in Chemical Engineering, April 1954, that no coating of 3½ mil thickness will last for as much as ten weeks in a common aggressive chemical-industrial atmosphere. Since a 1/8 in. thick coating of asphaltum mastic is 36 times as heavy as a 3½ mil thick paint system, the primary cause of paint failure is eliminated. This fact has been very well demonstrated by the extensive use of asphaltic underbody coating for automobiles during the past eight years. A paint system on the underside of an automobile will only last a short time, while a good heavy underbody coating will last the life of the automobile.

Heavy asphaltum mastic applications are protecting steel gas mains, water lines, pipe supports, quench or hot cars, conveyor bridges, coke batteries where the surface temperatures do not exceed 250 F, tar decanters, scrubbers, gas holders, storage tanks, etc., in coke plants. The same coating also has been used on the outside and inside of brick buildings, such as ammonium sulphate storage buildings, to protect the mortar joints

Figure 1 — The most corrosive spot in a steel mill is a breeze crane runway. The steaming coke quenching water and other refuse from the coke area enter the pit below the runway. The runway and superstructure are coated with mastic. Notice the condition of the uncoated structure at the extreme left.



*At time of paper presentation. Now with Philip Carey Co., Cincinnati, Ohio.

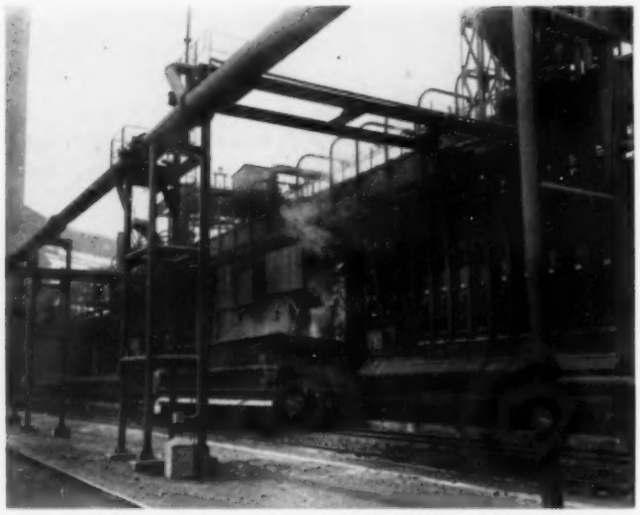


Figure 2 — The pipe and tubular supports in the foreground; the curved supports and cross-overs on top of the coke battery are all coated with mastic.

from being eaten away. After the brick surface has been properly prepared, the mastic is sprayed on to a thickness of 1/16 in. Immediately following the mastic application, colored roofing granules can be blown into the wet mastic for architectural appearance.

Mastic coatings are used to finish the exterior of thermal insulation. Because asphaltic coatings will waterproof porous surfaces, the coatings are used to weatherproof outdoor insulated pipes, vessels and tanks. Because asphaltic coatings are a barrier to water in the vapor state, the coatings are used to vaporseal thermal insulation on refrigerated units, lines and vessels. After a tack coat of mastic is sprayed over the insulation, glass fabric membrane is laid into the tack coat to reinforce the coating and to make a continuous vapor barrier package around the insulation. Following the installation of the membrane, a heavy finish coat of mastic is sprayed over the entire surface.

There are three very important primary conditions to be considered in order to obtain any successful protective coating application over steel. If any one of the three conditions is not fulfilled, the application will fail. The three conditions are: (1) proper material selection, (2) proper surface preparation, and (3) proper application.

Proper selection of material is important. Early failure may result if an inferior material is selected, even though it may be used in the proper place for that type of material. By the same token, it would do no good to select the highest quality material of a particular type and then to use it in a place unsuitable for that type of coating. The user should be familiar with the properties and limitations of the different types of organic coatings and paints so he can select the right type for a predetermined set of conditions. After the right type of paint or coating is selected, the user should then determine by controlled evaluation what brand he should use in order to obtain the best material available.

Mastics have their place in the protective coating field, and when applied in the proper place over a properly cleaned surface in the proper manner, long life can be assured. Asphaltum mastics will give good service on metal surfaces with temperatures varying from –20 F, to 250 F. If the surface temperature exceeds 250 F, for long periods of time, early failure can be expected. Petroleum and coal solvents will dissolve asphaltums, so, mastics are not recommended in areas where leaks or spillage of such solvents occur. Experience has shown asphaltum mastics are not at their best when used as tank linings, particularly acid tanks, but when used over metal or tile roofing, or over dry masonry walls of buildings, or on the outside of steel tanks, structural steel, piping, etc., the results are more than gratifying.

As stated before, no two mastics are ever the same formula because of the countless number of combinations obtainable from the many variations of raw material available. A quality coating is blended at the factory so that: (1) the fillers will not settle out, or the solvents seep to the surface during transit or storage, (2) no lumps or foreign objects will be present and the material will pump and spray through special spray equipment at an ever constant rate of flow without stoppage over a wide temperature range, (3) the material when spray applied, will have the ability to build a maximum thickness of 1/8 in. on overhead and vertical surfaces in one application over a wide temperature range without slippage, and (4) the material will spray on smoothly and uniformly without pin holes.

A quality asphaltum coating will dry with a minimum of shrinkage, and will be dry to the touch in less than four hours.

After a quality coating has cured, it will have good resistance to weather and chemical atmospheres, abrasion and impact, fire, heat and sub-freezing temperatures, and moisture vapor transmission. The coating also will have good adhesion, flexibility and be nontoxic.

The most accurate and best method of evaluating an asphaltum coating for the above characteristics is by field applications. Today, there are thousands of successful mastic applications serving industry from coast to coast in all types of atmospheres and climatic conditions. There are a number of successful applications dating back to 1938, the year this type of coating was introduced to industry. Mastic coating was introduced to the steel industry in 1946 in a pickling room, and the coating is still in good condition today. Since that time, the use of asphaltum coatings has spread throughout the coke by-product industries so that most coke plants have applications of this type in service today.

Although a test application in the field is the most accurate method of evaluating a coating, it consumes a great deal of time, particularly with heavy coatings. Accelerated tests in the laboratory are not as reliable, but they do speed up the time of evaluation considerably and help in making comparisons and weeding out the inferior coatings.

There are many good controlled laboratory tests that are being used today. The only characteristic about a mastic asphaltum coating that can be determined by observing the material in the drum is whether the material has remained uniform in consistency during shipment or storage, or whether the solvents have separated out and come to the top. Only controlled tests will properly evaluate all the other important physical properties and characteristics.

Weatherometer machines have been used to make accelerated weathering tests on mastics, but this accelerated test is still quite lengthy when testing heavy

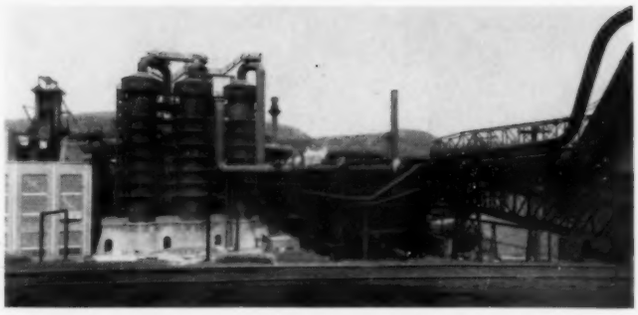


Figure 3 — In this gas cleaning plant for blast furnaces, all steel equipment, except gate valves, has been coated with mastic.

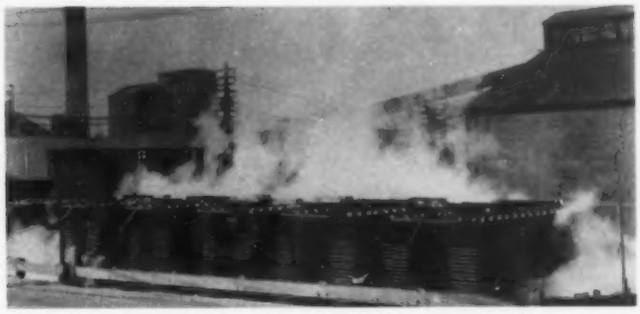


Figure 4 — Constant water showers seen inside these coolers result in steam continuously surrounding the structure.

coatings. The most acceptable method is to expose several specimens to either infra-red lamps for a period of thirty days or to place them in an oven at 125 F, for thirty days. After this exposure, the specimens are tested for impact strength, using a Gardner Senior impact testing machine; hardness, tested in accordance with ASTM Procedure D 676-49T; flexibility, as indicated by fracture point in degrees of bend around a ½-in. mandrel at such temperatures as 0 F, and 30 F; tensile strength and percentage of elongation, tested in accordance with ASTM Procedure D 882-49T; shrinkage determined by visual measurement and expressed in percentage of shrinkage by volume, linear, and thickness. The results of these tests are then compared with similar results of the same tests when made with specimens that have been air dried at room temperature.

The next characteristic of importance to test is the permeability of the film. This test is an indication of the coating's resistance to moisture absorption, the amount of moisture that can be expected to penetrate the film and attack the surface to which it is applied, as well as an indication of the film's continuity. The dry cup procedure for moisture vapor transmission has proven inadequate for the evaluation of mastic coatings, so the wet cup method is definitely recommended because it is more indicative of actual service conditions. A wet surface increases the moisture vapor transmission rate considerably, and in the wet cup method the surface of the coating being tested is periodically splashed with water, which simulates outdoor field conditions.

Adhesion of the mastic to the surface is also an important characteristic. Two test methods are usually used to determine this factor. Results after exposing specimens to a salt spray when run in accordance with ASTM Procedure B-117-49T will indicate the affinity of the film to a surface in the presence of moisture. Adhesion of the film under dry conditions is determined by the Gardner laboratory adhesion method when using a Gardner tensile strength apparatus.

There are many other tests that can be made which have varying degrees of importance depending upon the specific application. Among these are fire resistance, slide test for slippage, acid and alkali resistance, toxicity, flashpoint of incorporated solvents, viscosity, penetration, drying time and temperature resistance.

After the type of coating has been selected and tests have been made to select a particular brand, the next step is surface preparation, the second important condition.

Proper surface preparation before the application of any protective coating cannot be over-emphasized if long life is expected in an industrial chemical atmosphere. No paint or coating will last long when applied over rust, scale, dust, oil, loose paint or moisture. There are oil paints that have good penetration and wetting properties that can overcome superficial loose rust and moisture, but these paints have poor resistance in heavy chemical atmospheres.

When old steel is badly corroded, and where permissible, there is no better cleaning method than sand-blasting, for it is the most thorough and most economical method for the results obtained. There are other methods of cleaning corroded and contaminated steel to be sure, such as wire brushing, chemical, chipping and flame cleaning, but the cost will be higher to obtain the same results. Steel Structures Painting Council has published a set of specifications for all the different methods for the preparation of metal surfaces. The Council has divided sand-blasting into three specifications:

1. SSPC — SP5-52T August 28, 1952 — Blast Cleaning to "White" Metal.
2. SSPC — SP6-52T August 28, 1952 — Commercial Blast Cleaning.
3. SSPC — SP7-52T August 28, 1952 — Brush-Off Blast Cleaning.

The latter is generally acceptable for most asphaltum mastics, and for most industrial conditions. The definition of Brush-Off Blast Cleaning is the removal of loose mill scale, rust and paint by impact of propelled abrasives and the abrading of the surface for good adhesion and bonding of the coating. The sand used for blasting should be a hard silica sand with a large grain size and free of clay. The large sand particles will do the job

Figure 5 — The understructure of these cars receives a bath of scalding, acid laden water every time a carload of red hot coke is quenched. Without a coating, the car would last only eight months.

faster and will give a satisfactory anchor pattern for asphaltum coatings.

In a chemical atmosphere, the cleaned metal surface must be coated immediately, or the surface will become contaminated. A metal primer is not necessary underneath asphaltic coatings except in certain instances, such as:

1. When the protective coating cannot be applied immediately over a cleaned surface.
2. When the surface is colder than the ambient temperature.
3. When the surface is to be submerged in water or exposed to water spray.

Although a primer is not necessary in most instances, a good primer that is also resistant to the same environment to which the top coat is exposed, will add a safety factor in case the top coat is damaged. General purpose primers with oleo-resinous, vinyl or alkyd binders that contain zinc chromate, iron oxide or both as pigments work very well with asphaltums. Modified phenolics with zinc dust do a good job in submerged areas. Vinyl wash primers have several advantages and disadvantages. It is a conditioner as well as a primer which is good and it is very resistant to chemical atmospheres. The disadvantages of a vinyl primer are its temperature limitation at around 160 F, and its trickiness of application for an inexperienced crew. Primers should be thoroughly dry before top coatings are applied.

The third important condition to be emphasized is application. One can determine the correct type of coating and select the best of its kind for a certain job. He can clean the metal well, but if the good coating is improperly applied, the job will have a short life. The user should train his own crews properly or be selective when awarding a contract for application. Complete specifications should be written beforehand, and the job should be inspected to see that the specifications are followed.

In severe chemical atmospheres such as most coke plants, the mastic asphaltic coating should be applied from a minimum, not an average, thickness of $\frac{1}{16}$ in. which is 7 to 8 gal per 100 sq ft, to a $\frac{1}{8}$ in. thick, which is 10 to 12 gal per 100 sq ft depending upon the severity of the environment. To obtain a good coating, the mastic must be applied uniformly and as smoothly as possible. To obtain this performance, correct and good equipment is necessary. The equipment should include an automatic air valve to synchronize the pumping equipment with the spray gun, air regulators and gages to obtain positive control of pump operation and atomization air, and a moisture trap to bleed water out of the atomizing air supply. The latest equipment on the market to improve application of heavy mastic coatings is an electrical resistant type heater that is inserted in the material hose about 10 to 15 feet behind the spray gun. This heater has introduced hot spraying to the mastic protective coating field. Spraying mastic coatings hot has many advantages:

1. Application is faster, reduces viscosity.
2. Coating is smoother and more uniform, lower viscosity and less atomization air pressure.
3. Coating has less shrinkage — high rate of solvent loss at gun nozzle.
4. Stops pulling and thinning at edges — less atomizing pressure and less shrinkage.
5. Faster drying time — less solvents.
6. Saves money — faster, less air compressor requirement, less tiring to sprayman because of smaller material hose at spray gun.

The hot spraying of a heavy coating will help make an inexperienced sprayman look good.

During an application, the thickness should be periodically checked with a toothpick, sharp pointed instrument or a magnetic thickness gage. After the coating has cured, the thickness can be checked with a depth pit gage or magnetic thickness gage. A holiday detector can be used, if desired, to make absolutely certain there are no pin holes in the coating.

Heavy asphaltum mastic coatings pick up the job of protecting steel and masonry in coke plant areas where paint systems leave off. Mastic coatings are not replacing paint, where paint is doing the job in less severe areas. Mastics are supplementing paint as a material to handle the really tough corrosive jobs. Select a good material, prepare the surface properly, and apply the coating correctly, and years of maintenance free service will be obtained.

DISCUSSION

PRESENTED BY

R. A. MILLER, Project and Control Engineer, Inland Steel Co., East Chicago, Ind.

ABNER H. BAGENSTOSE, JR., Eastern Regional Manager, Insul-Mastic Corp. of America, Pittsburgh, Pa.

S. C. FRYE, Research Engineer, Bethlehem Steel Co., Bethlehem, Pa.

JOHN F. BOAL, General Supervisor Maintenance Development, United States Steel Corp., Clairton, Pa.

R. A. Miller: Mr. Bagenstose's paper gives a clear, understandable description of the many uses of heavy asphaltum coatings in the protection of steel and masonry in coke plant areas. However, I believe that a table which would give a listing of the various grades of coatings, methods of application and recommended usage would be helpful in the preparation of specifications for the average engineer in issuing inquiries for contract applications.

Various types of heavy coatings are used at Inland for waterproofing to coke plant areas. All corrugated steel roofs are coated with a heavy asphaltum coating. We clean the surface by wire brushing and scraping, apply a primer coat and finish with $\frac{1}{8}$-in. thick coating of mastic, reinforced with mineral filters.

Structural steel surfaces, gas mains and storage tanks in the coke plant are covered with bitumastic paint applied by spraying over a primer coat. This is preferred over the thick mastic coating due to the tendency of moisture to collect in breaks in the thick coating, causing corrosion not observable until large blisters appear.

Our ammonium sulphate storage areas are coated with a coal tar pitch material on walls and concrete floors for protection against the corrosive action of the salt.

An inert material is introduced into the water seals

of the gas holder once a year, which provides an oil film on the inside and outside surfaces of the gas holder.

In our steam pickle building we are using rubber base paints, usually applied in seven coats, on the steel work, sheeting and exhaust fans. The use of this material has not been too successful and I would like to inquire of Mr. Bagenstose whether he can give any information on the use of asphaltum mastic coatings in pickle buildings, and a comparison of costs of this type of coating with resin and rubber paint application.

Abner H. Bagenstose: Steel companies have used mastic coatings on structural steel of pickling houses and it has worked out very well. In fact, one of the first applications in one of the largest mills in the East was done about seven to eight years ago in such a building, and the last report I have had is that it is holding up very well.

I cannot compare the price of mastic against rubber coatings as I have no idea what the price of rubber is.

Member: It is $4.95 a gallon, and covers about 400 sq ft to the gallon.

R. A. Miller: I would say, not including the cleaning, the price of the mastic would possibly be double the application of a three-coat paint system.

S. C. Frye: Mr. Bagenstose has presented here a paper on heavy asphalt mastic coatings which gives a good general outline for the successful use of these coatings. Their use in protecting structural steel work in the severely corrosive areas found in coke oven plants has been one of several aids in reducing maintenance costs in coke oven plants.

The three conditions named as necessary for a successful protective coating application, namely proper material selection, proper surface preparation, and proper application, are all so tightly tied together that if one of these conditions is not met poor performance will result. It is difficult to determine which is most important. While it has been said that, with ordinary paint, good surface preparation will have at least a 75 per cent effect on the resultant performance of the ordinary paint, it is difficult to determine if there is any percentage like this in the use of heavy mastics. Surface preparation is either good or no good and only time will tell in the effect it has on the performance of the mastic.

Application and thickness of coating go together. Here workmanship is very important. Poor "know how" in applying mastics can result in "pin holes" and uneven film thicknesses. These defects in application can result in rusting under the mastic with consequent failure of the mastic coating to provide protection.

Thickness of the coatings cannot be ignored or passed over lightly. A thickness gage has been mentioned as a means of measuring the thickness of the mastic coating. However, because of the uneven surface ordinarily obtained in spraying mastics, this instrument seems to give the average thickness between the gage pins rather than the thickness at a point. We have developed another simple gage to measure thicknesses at one point. It is made by cutting the first head off of a two-headed nail. The remaining stub is sharpened and its length is the required mastic film thickness. If the coating is the desired thickness the second head will come flush with the coating. If too thin, there will be an air space and conversely if too thick, the head will go into the coating. This gage should be used immediately after the mastic has been applied and is still wet. Adjustments in film thickness can then be easily made.

Inspections at regular intervals should be made of all mastic applications. This should be done to determine their performance and detect any signs of failure that can occur which are usually due to faulty application or surface preparation.

J. F. Boal: One of the major problems in coke plant maintenance is the prevention of untimely destruction of steel and concrete structures exposed to corrosive elements in the atmosphere of this industry. A by-product coke plant is essentially a chemical producing plant and as such the gases and vapors present in the atmosphere which accelerate electro-chemical corrosion are much the same as in all chemical plants.

The painting practice in these areas, in the past, has not been essentially different from that practiced in any other industrial area until the development of heavy mastic coatings began to be accepted within the past few years. The former practice consisted of hand cleaning and the application of a coat of paint about one or two mils thick every one or two years or oftener.

The disadvantage of this procedure was that it did not adequately protect the painted structure. The thin paint films failed in a few months due either to a breakdown of the film or to continued corrosion under the film because of inadequate surface preparation, so that within a few years costly replacement of structures was necessary. The cost of frequent cleaning and painting was also very high.

In an effort to extend the life of various coke plant structures such as process and storage tanks, overhead pipe lines and their supporting structures, and miscellaneous structural steel work, some coke plants have adopted a program of sand blasting the steel to bare metal and applying a thick coating of heavy mastic material. These coatings have largely consisted of various compounds of asphalt resins with filler materials, wetting agents and plasticisers.

The theory behind this coating system is: first, the steel is cleaned of all corrosive elements and products of corrosion so that under film corrosion will not proceed after painting; second, a coating will be applied which will adhere firmly to the clean surface of the steel, will be relatively inert to the usual atmospheric corrosive element, and will remain plastic and flexible over a long period of time; and third, a coating will be applied thick enough to minimize the possibility of early film failure due to pin holes or cracks developing in the coating.

The initial cost of a sand blasting, mastic coating job, using the usual current methods, may be four to six times the cost of hand cleaning and brush painting. However, the present indications are that this coating system will, because of its long life, prove economical for two reasons: first, the coating will last long enough to justify its cost; and second, because the coating does last longer than ordinary painting the structures themselves will not deteriorate and plant maintenance and replacement costs will be considerably reduced.

At the Clairton Works of the United States Steel Corp. we have the largest by-product coke plant in the world, and we of United States Steel are proud of our plant. Our job is to maintain these plants at lowest cost. We have been using a considerable quantity of asphalt-

mastic coating material during the past four years as a part of our effort to reduce costs. At this time we feel justified in extending the use of it to most of our structures located in the more severely corrosive areas.

Our practice is to sandblast the structure and apply the mastic coating the same day by spraying it directly on the clean steel surface. We have established by experience that sufficient mastic must be applied to result in a minimum dry film thickness of about one-sixteenth of an inch. Because of the impossibility of obtaining an absolutely uniform thickness by hand spraying, the average dry film thickness will be about $\frac{3}{32}$ in. and the wet film thickness will be about $\frac{1}{8}$ in. To obtain this thickness, it is necessary to use between seven and eight gallons of mastic material for each 100 sq ft of area painted.

We agree with Mr. Bagenstose that good inspection is essential to proper application of mastic coatings. Our practice is to assign a full time inspector to work with a contractor or our own forces in each area being coated. It is one of his duties to check the thickness of the wet film enough times to assure us that we are putting on a uniform coating of the required thickness.

At the beginning of a job it is generally necessary to work very closely with the men performing the work and instruct them in the proper method and technique to use in applying this type of material in order to insure as much uniformity as possible.

We have examined our mastic coatings periodically by cutting through them with a knife to permit an inspection of the quality of adhesion and the condition of the steel. We have found that, where the mastics have been properly applied and in adequate thickness, they are maintaining excellent adhesion to the sand-blasted steel, and the steel is free from underfilm corrosion. Also, the mastics are retaining much of their plastic characteristics after three years in service.

We plan to inspect our mastic installations on a regular schedule and make prompt repairs to any local areas in which the mastic film has become damaged.

We have encountered early failure of the mastic system under three types of conditions. These are where the mastic has not been applied to a sufficient thickness, where application has been over a hand cleaned rather than over a sandblasted surface, and where ammonium sulphate salt comes into direct contact with the coated steel structure. In the latter instance, the ammonium sulphate, or possibly the small amount of free ammonia generally associated with it in our plant, penetrates the coating and aggressively attacks the steel, particularly when moisture is present.

We have not had experience with hot spraying of mastics, but in view of the advantages mentioned by the author, it would seem to be a method worthy of consideration. I would like to know at what temperature hot spraying would be carried out and also whether hot spraying introduces any hazards to the men performing the application.

Abner H. Bagenstose: The object is to spray the material as hot as possible at the nozzle. The people manufacturing these heaters have been constantly improving them; making them larger, with more wattage, to get the heat.

The average temperature now obtained by commercial heaters is around 150 F at the nozzle. Sometimes it is a little higher. To obtain this temperature they use a hose as small as possible in diameter, about three-eighths of an in., from the heater to the gun. The heater is inserted as close as possible, say 15 ft, to the spray gun.

I have never heard of any hazard to the applicator applying mastics hot. If the mastic is sprayed hot into one's hand it will not feel hot, because the mastic cools very rapidly due to the violent release of heated solvent.

SMOKE DENSITY CHART REISSUED BY BUREAU OF MINES

▲ RESPONDING to increased public interest in air pollution problems, the Bureau of Mines has just issued a new edition of the "Ringelmann Smoke Chart," a standard guide often used in developing and enforcing smoke-control regulations.

Named after its originator, Prof. Maximilien Ringelmann of Paris, the first chart was prepared more than 50 years ago and today is widely used as the standard for determining the density of smoke from industrial and commercial stacks and other installations.

The chart consists of special cards which appear as graduated shades of gray when mounted some distance from an observer and in line with the stack or chimney being observed. The observer then determines which shade of gray most nearly matches the smoke coming from a stack. Many smoke-control regulations list violations in terms of the duration of smoke emission and the density as compared with the Ringelmann scale.

According to a Bureau circular accompanying the Ringelmann Chart, the standard was introduced to the United States in a magazine article in 1897. In 1904 it was employed by engineers of the Technologic Branch of the Geological Survey (later the nucleus of the present Bureau of Mines) in studies at St. Louis. By 1910, the Ringelmann Chart gained additional prestige when the Massachusetts Legislature recognized it officially in a smoke ordinance for the city of Boston.

The Bureau's new publication describes use of the scale and contains a chart for making observations of four densities of smoke, ranging from No. 1 to No. 4. Omitted are No. 0, a clear stack, and No. 5, wholly black smoke.

Single copies of I. C. 7718, "Ringelmann Smoke Chart," by Rudolph Kudlich (revised by L. R. Burdick), containing one copy of the chart itself can be obtained from the Bureau of Mines, Publications-Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa. Additional copies of the chart are available from the same source. The chart should be identified by title and the publication by both number and title.

Power and Control Cables for steel mills

By E. D. YOUMANS

Vice President, Research and Product Development, The Okonite Co., Passaic, N. J.

. . . . progress in the art of insulated wire and cable is keeping pace with the increasing requirements of steel plants . . . . available are many adequate and dependable designs for each particular need . . . .

▲ ELECTRICAL equipment is an essential part of a steel mill. Its importance needs no emphasis. Service conditions vary greatly and may be severe, often involving high temperature and corrosion problems. The best and most dependable wires and cables for the purpose are required to prevent costly power interruptions and shut-downs.

HIGH VOLTAGE POWER CIRCUITS (OVER 5000 V)

Some steel mills generate their own electric power. Others are supplied by electric utility companies. Many mills have both their own and purchased power. In any event, it is necessary to provide large amounts of power at various locations in the works, some of which may be at considerable distance from the power house or substation. Most of such power is distributed to the point of use in the mill at higher voltages, i.e. above 5,000 v. The engineer must decide whether to go underground or overhead.

Underground—Preferred practice in most steel mills is to install high-voltage power cables in underground conduits and tunnels, particularly where a group of cables must be run along together in the same direction or location. Underground installation is higher in cost than overhead or aerial construction but has several worthwhile advantages. Perhaps most important is that underground cables are out of the way and less likely to be an obstruction or occupy space needed for other purposes. Appearance and lower susceptibility to damage by storm, fire, cranes and other causes are also factors in favor of underground installations.

Cables are often installed in tunnels or underground raceways and in basements of buildings. This is good practice but care must be exercised to provide adequate spacing between power cables to prevent overheating. Be sure that the cables are not subject to external heat such as from steam lines.

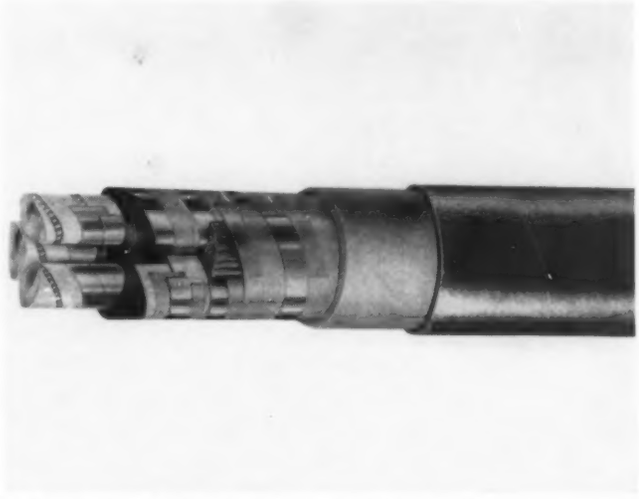


Figure 1 — Cable shown is three-strand solid type, paper insulated, lead-sheathed, with corrosion protective covering.

Cables are also buried direct in the earth. For maximum mechanical protection, steel tapes or round steel wire armor are applied over the lead. However, this method of installation is usually limited to an isolated run of one or two cables. Conduit installation is preferable for groups of cables placed underground.

High-voltage power circuits are of so much importance to the operation of the mill that the best cable and type of installation should be used.

Oil impregnated paper insulated, lead covered cables are in general use for high-voltage, underground power circuits (Figure 1). The lead sheath should have a corrosion protective covering preferably made with

neoprene. Lower cost as compared with rubber insulated or varnished cambric insulated cables is an important advantage in favor of paper insulated cables. A further advantage is their small size or diameter because the paper insulation thickness is less. Compact strand and sector conductor shapes result in additional reduction in diameter. Paper insulated cables provide reliable service for high-voltage purposes and find frequent applications especially as the operating voltage goes up above 15,000 v.

Proper care during installation and well-made splices contribute much toward freedom from troubles. Needless to say, only workmen who are trained and experienced in the installation of lead covered, paper insulated cables should be employed for this purpose since it is imperative to have joints that will keep moisture out.

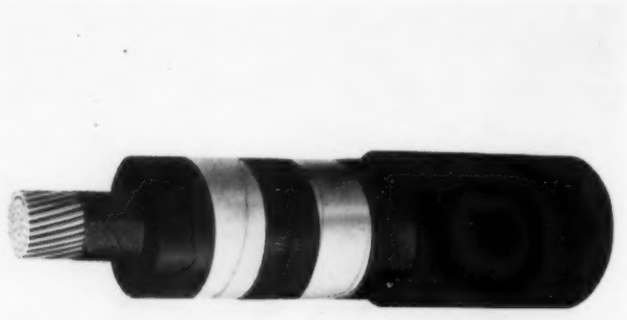


Figure 2 — A single-strand, rubber-insulated, shielded, neoprene-sheathed, 15-kva cable is shown.

Lead sheath corrosion has been a major cause of underground cable failures. This has been corrected by the application of a protective covering over the lead sheath. A large amount of cable is furnished with a neoprene compound jacket for its outer covering. There has been more than 20 years experience with such a covering with excellent results. Reduced lead sheath thicknesses may be used under the neoprene protective covering.

Rubber insulated, shielded, neoprene sheathed cables are frequently used for high-voltage underground circuits (Figure 2). An oil-base, ozone resistant compound is the preferred type of rubber insulation for such service. There are several reasons why rubber insulated cables are favored by engineers for certain installations. Perhaps one of the main considerations is the lack of skilled paper cable splicers. Many mills do not have these men as regular employees and are therefore not prepared to do a proper splicing job, especially making a satisfactory watertight wipe of a lead sleeve or pothead to the cable sheath. This can be important in an emergency where it is necessary to restore service quickly. Rubber insulated, shielded, neoprene sheathed cables are easier and simpler to splice. They do not involve maintenance of a continuous lead sheath. Splicing and terminating can be done by the works electricians. These non-leaded, rubber insulated cables are often terminated without potheads. There are many electrical engineers who do not like to use potheads if they can avoid it.

Other factors in favor of rubber insulated cables include lighter weight and better flexibility making them easier to handle. Moisture and corrosion are not problems, and there is no oil or petrolatum in the cable to migrate at high temperatures or due to differences in elevation. High-voltage circuits often rise up out of the ground to locations at sufficient height to cause a substantial static head or pressure at the bottom of the run in the case of oil impregnated paper cables and varnished cambric cables. At times the static internal pressure in the cables becomes sufficient to cause the lead sheath to expand and burst which cannot occur with a rubber insulated cable.

Rubber insulated, shielded, neoprene sheathed cables may be installed in underground conduit, in tunnels or buried direct in the earth.

Where a cable is buried direct it is always desirable to have ample protection such as steel tapes or round steel armor wire such as are essential for buried lead-covered paper cables. If a non-metallic sheathed cable is buried direct, it is good practice to place a concrete slab in the ground to protect the cables against future excavation.

In general, it is preferable to use a multi-conductor cable for direct burial, since this design offers a more rugged construction, is easier to install and prevents the possibility of trouble from cross-overs or stone bruises. The extra cost of the multi-conductor cable design is often offset by the use of a narrower trench and the reduced possibility of damage and subsequent outages and repairs. Where groups of cables are required it is usually preferable to install them in conduits rather than by direct burial.

Because high-voltage circuits are main feeders, the most reliable cable obtainable should be used. The purchaser should require every assurance that the manufacturer can furnish dependable cable as proved by an adequate record of satisfactory actual operation in such service.

Figure 3 — Varnished cambric insulated, lead-sheathed cable is sometimes used in high voltage underground circuits.

Varnished cambric insulated, lead covered cables are sometimes used for high-voltage underground circuits (Figure 3). Their use for this purpose has, however, decreased considerably in recent years. More trouble than is desirable has been experienced with varnished cambric cables in service at voltages above 5,000 v. They are higher in cost than paper insulated cables and are larger in size. Skilled splicers who can make dependable soldered lead joints are also required. The lead sheath should have a neoprene covering for corrosion protection.

Aerial or overhead—Steel mills frequently run high-voltage power circuits overhead, outdoors, also occasionally indoors when heat is not excessive. These are installed on poles and cable towers or on racks attached to buildings. Bridge structures are at times built to support large groups of overhead cables together with other utilities including steam and water pipes. Generally speaking, the same types of cables as are used in underground ducts can also be installed overhead.

Bare or triple-braid weatherproof conductors installed on insulators have been used on a large scale for high-voltage, overhead lines. This provides a low cost design. The great increase in the amount and number of applications for electric power in steel mills in recent years has, however, resulted in the installation of much more insulated aerial cable than in the past. Space limitations or congestion, especially as the working voltages and number of such circuits have increased, are often reasons for the choice of insulated aerial cables. Dependability in case of storms and other emergencies, safety and appearance are additional considerations.

Recent years have witnessed the development of a factory-assembled rubber insulated, neoprene sheathed, self-supporting aerial cable which is useful for overhead distribution in steel mills (Figure 4). Large footages of this cable are in service at from 5,000 v to 15,000 v. It is easy to install and is a good solution for the spacing problem as well as providing assurance against accidents and storms. Improved reactance is another advantage. This pre-assembled, self-supporting cable is installed outdoors on poles or towers and on racks attached to buildings. See Figure 5. It is also used indoors where it may be suspended from the building structure or trusses and provides a dependable installation.

Figure 5 — Self supporting cable installation at steel plant shows use of existing plant structures for support.

Interlocked metal tape armor cables are another design which are of interest to steel mills for overhead installation, both outdoors and indoors (Figure 6). Rubber insulated conductors are recommended for the best assurance against trouble and are most desirable where the cables might be exposed to moisture as in outdoor aerial service. Oil-base, ozone resistant rubber compound has established itself as the preferred rubber installation. Galvanized steel is the most economical and widely used metal for interlocked armor cables. It is usually satisfactory for indoor installation conditions. Where corrosion might be encountered, interlocked copper, bronze or stainless steel tape should be considered. For outdoor installations copper, bronze or aluminum armor may be desirable.

Interlocked metal tape armor cables are also furnished with varnished cambric insulated conductors (Figure 8). A moisture-resistant, impervious sheath

Figure 4 — This 15,000-v rubber-insulated, shielded, neoprene-sheathed, aerial cable is self supporting.

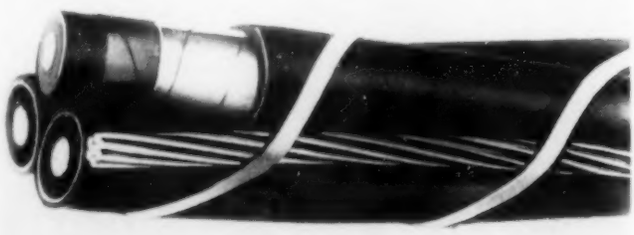
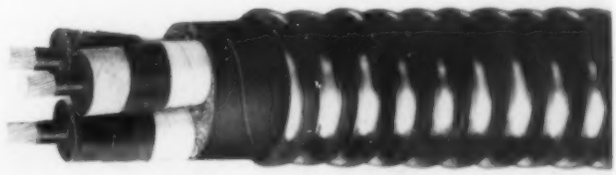


Figure 6 — This rubber-insulated, shielded, interlocked, 15,000-v cable is used in an aerial installation.



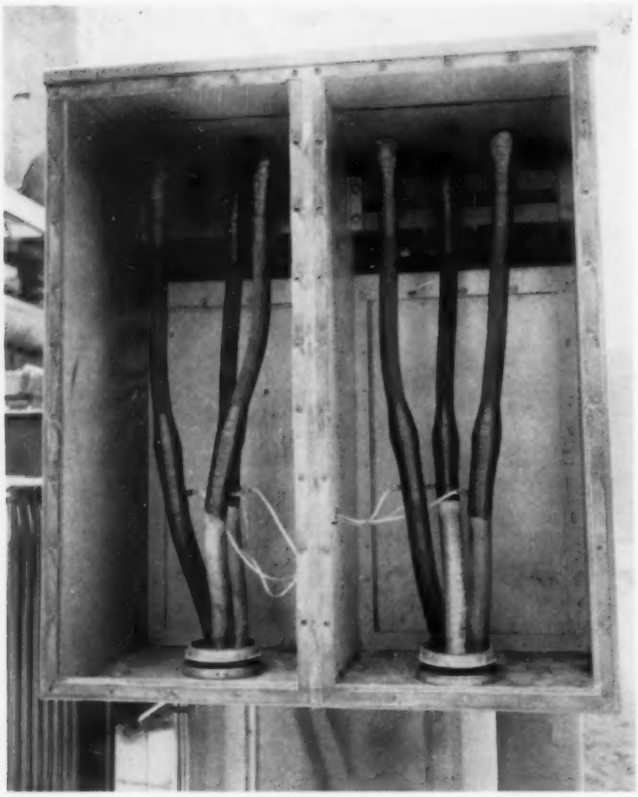


Figure 7 — View of cable terminals in cable compartment in an outdoor substation shows stress cone make up and shielding tape ground connection.

should be included under the interlocked armor to prevent the entrance of moisture into the varnished cambric insulation.

Interlocked metal tape armor cables are relatively easy and inexpensive to install as compared with cable in conduit. They are supported on trays, racks and brackets or may be clamped to the building structure similar to conduit. Accessories such as supports, clamps, trays, racks and terminators specially manufactured for installing interlocked armor cables are available.

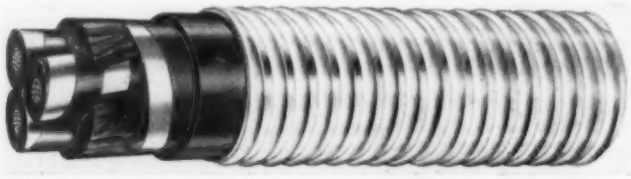


Figure 8 — Cable shown is 15,000-v, varnished, cambric-insulated, shielded, moisture proof sheathed and metal armor interlock.

Generator, transformer and apparatus cables—Rubber insulated, shielded, neoprene sheathed cables have several desirable features which make them well suited for high-voltage leads and connections (Figure 9). An oil-base, ozone resistant rubber compound should be used for the insulation. Advantages of this type of cable include:

1. Lighter weight and easier handling.
2. Greater flexibiilty for installing.
3. Simpler terminating and splicing.
4. Potheads are usually unnecessary.
5. Moisture does not affect the insulation.
6. There is no oil or petrolatum in the cable to migrate at high temperatures or due to differences in elevation. Therefore, there is no bleeding at ends.
7. Replacement of lead by neoprene for the sheath eliminates electrolytic or chemical corrosion and fatigue. Possibility of mechanical damage is reduced.
8. Neoprene sheath is non-flammable, weatherproof and oil-resistant.

Oil-base, ozone resistant rubber insulated, shielded, neoprene sheathed cables are being used for high-voltage power leads operating at 35,000 v for arc furnaces (Figure 10).

2001 TO 5000-V POWER CIRCUITS

Steel mills distribute and use large amounts of electric power at 2,300 v. Also there are many circuits operating at 4,160 v and other voltages in the 2,001 to 5,000-v range. Practice with respect to underground versus overhead installation is much the same as for higher voltage (over 5,000 v). Underground installation is generally preferred, but there is a great amount of overhead construction. However, a much larger proportion of the 2,001 to 5,000-v circuits is located indoors in buildings and many of the runs are shorter than in the case of the higher voltages.

Underground—Most steel mills install outdoor 2,001 to 5,000 v circuits underground in conduits or tunnels. The cost is greater than for overhead construction, but the advantages, as described earlier for higher voltage lines, usually justify the additional expense.

Non-shielded rubber insulated, neoprene sheathed cables provide a simple and dependable design for underground service at 2,001 to 5,000 v (Figure 11). While metallic shielded, rubber insulated cables are sometimes recommended and used for this purpose, the use of shielding complicates splicing and terminating and is frequently a cause of trouble. This is particularly true where it is necessary to make connections in small boxes on motors or apparatus. Non-

Figure 9 — This rubber-insulated, shielded, neoprene-sheathed, 15,000-v, generator lead has a segmental conductor.

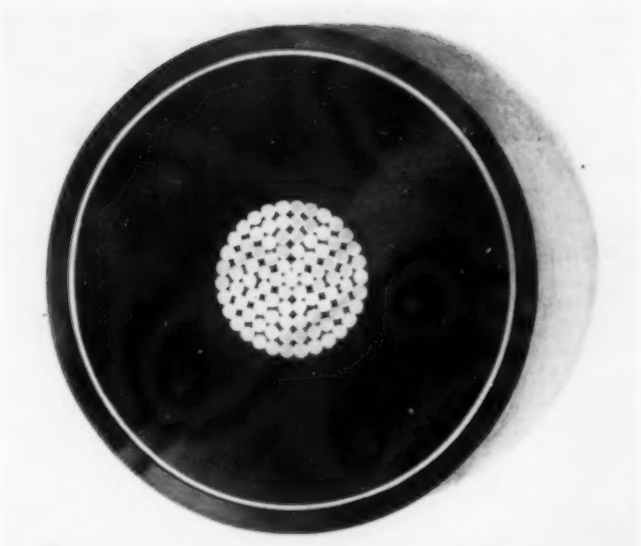


Figure 10 — Cross-section through rubber-insulated, shielded, neoprene-sheathed 35,000-v cable is used as a power lead for arc furnace transformer.

shielded rubber insulated cables having the proper characteristics and quality are preferable.

Varnished cambric insulated, lead covered cables are used in many steel mills for underground service at 2,001 to 5,000 v. The lead sheath should have a corrosion protective covering made with neoprene.

Aerial or overhead—A large amount of wire and cable operating at 2,001 to 5,000-v is installed overhead, outdoors in steel mills. It is supported on poles, towers and on racks or brackets attached to buildings. Triple braid, weatherproof conductors are largely used for this service. The increased number of wires and cables now necessary often result in badly crowded conditions. Insulated conductors should be considered for such places.

Factory-assembled rubber insulated, neoprene sheathed self-supporting aerial cable is especially useful to relieve congestion of overhead lines (Figure 12). It is furnished without metal shielding for use up to 5,000 v and provides a simple design that is easy to tap, splice and terminate. Reduced clearance space required near buildings and other structures is often a further advantage. Self-supporting cable gives better voltage regulation due to lower reactance than spaced bare or weatherproof conductors.

Interlocked armor cables may be used in place of weatherproof conductors for outdoor, overhead installation for the same reasons as given above for self-supporting cables. Ozone resistant, oil-base rubber insulated conductors are recommended, but a large amount of interlocked armor cable is furnished with varnished cambric insulation. A moisture-resistant sheath should be included under the interlocked armor on varnished cambric insulated cables installed outdoors.

Indoors—2,001 to 5,000-v power circuits in steel mills are installed indoors on racks in basements, tunnels and raceways. Many runs are in steel conduit. Cables are also placed overhead attached to trusses and the roof structure.

Rubber insulated cables and varnished cambric insulated cables are both used widely for indoor service in steel mills at 2,001 to 5,000-v. The moisture-proof nature of rubber insulation makes it preferable to braid covered varnished cambric. Non-shielded, ozone resistant, oil-base rubber insulated, neoprene jacketed cables are recommended. This design is dependable and has many desirable features including ease of handling and installation. Self-supporting, rubber insulated cables and interlocked armor cables, either rubber insulated or varnished cambric insulated, should be considered for overhead circuits attached to the building structure. Interlocked armor cables for indoor installation are generally furnished with galvanized steel armor because of its lower cost compared to bronze.

0 TO 2000-V POWER AND CONTROL CIRCUITS

Low voltage (0 to 2,000-v) wires and cables in steel mills are subject to all of the same service conditions as the higher voltage wires and cables. Low voltage circuits are, however, frequently located where they are exposed to more severe service conditions such as heat and oil. Also there is much direct current used for both power and control purposes. It is important that low voltage circuits be dependable. Only the best quality and type of wire and cable for the service should be used.

Rubber insulated wires and cables are generally used for low voltage service. There are, however, substantial amounts of triplebraid, weatherproof conductors used for open wire overhead lines. Asbestos and asbestos-varnished cambric cables are installed in locations involving high temperatures such as on overhead cranes. Thermoplastic polyvinylchloride insulated

Figure 11 — Single-strand, rubber-insulated, neoprene-sheathed, non-shielded cable is used in underground service up to 5000-v.

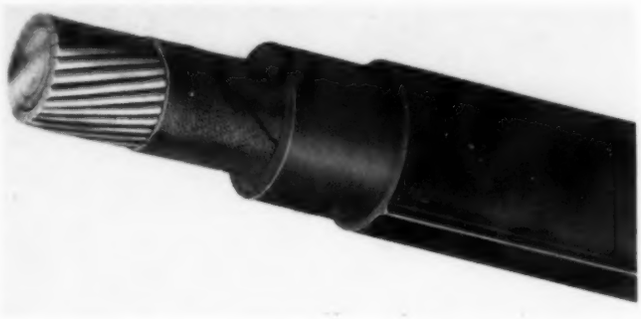
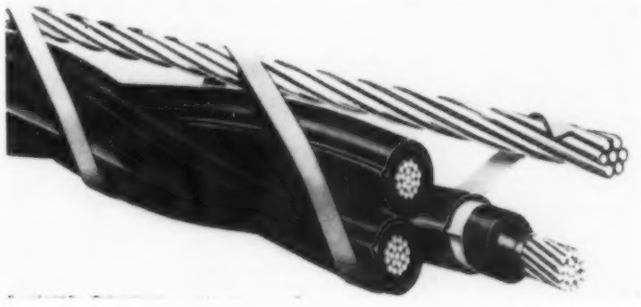


Figure 12 — This three-strand, rubber-insulated, neoprene-sheathed, non-shielded 5000-v aerial cable is self supporting.



wires (Type TW) in the smaller sizes are sometimes used in places where continuous oil exposure exists such as in the control panels at cold strip mill rolling stands.

Ease of handling and installing together with good mechanical properties and moisture resistance, are largely responsible for the general use of rubber insulated wires and cables for low voltage circuits. Long and satisfactory experience is another factor. Most of the rubber insulated wires and cables are now furnished with a neoprene jacket or sheath applied over the rubber insulation. A neoprene sheath of proper quality has many desirable characteristics and advantages including the following:

1. Weather proof—Neoprene sheathed cable exposed to sunlight and weather extremes for 20 years is still in excellent condition and looks as it did when new.
2. Moisture resistant—Neoprene sheaths will not rot or deteriorate when subjected to moisture as compared with braid coverings.
3. Chemical resistant—Neoprene sheaths have excellent resistance to most acids and other corrosive chemicals which destroy braids, lead and other cable coverings.
4. Oil resistant—Neoprene sheaths are not oil-proof but do provide protection for the rubber insulation where oil exposure is not continuous.
5. Non-flammable—Neoprene sheaths do not support combustion or contribute to fire.
6. Withstand cold—Neoprene sheaths are flexible at temperatures even lower than minus 18 C (0 F) and may be handled in the coldest weather.
7. Heat resistant—Neoprene sheaths are stable and have long life in warm locations where the temperatures do not exceed the limitations for rubber insulated conductors. There are no saturants or finishes to soften and flow or become tacky at elevated temperatures.
8. Dielectric quality — Neoprene sheaths provide additional dielectric strength. High surface resistance eliminates end leakage at terminals. Neoprene coverings do not need to be cut back like braids and other fibrous materials.

Some steel mill electrical people prefer braid-finished, rubber insulated conductors, particularly in the smaller sizes, because they are easier to pull into conduit than the neoprene covered type. The pulling problem can be largely overcome by means of a few simple precautions. First check the conduit and wire sizes to be sure the approved "fill" will not be exceeded. Do not "crowd" the conduit. Apply over the wire or cable a thick solution of water and soap flakes or a mixture of water and soapstone. These materials can also be used to pre-lubricate the conduit in long and difficult runs at the time the plug is pulled through to check for obstructions. Also, there are many commercial pulling lubricants on the market which are satisfactory for use on neoprene covered wire. Care should be taken to avoid cross-overs in the wires as they enter the conduit.

There has been some experience to indicate that braided constructions might hold up better than neoprene-covered constructions in conduit exposed to high temperatures. Apparently the braid serves to hold the rubber insulation together longer than neoprene after the insulation has been baked out and destroyed by heat. It would be preferable to consider for these locations cables with a better heat resistant type of insulation such as silicone rubber. This will be discussed later in this paper.

Wires and cables in single conductor form are generally used for the low voltage power circuits in steel mills. For control wiring some use only single conductors, but the majority use a large amount of multiconductor control cables. Control circuits, whether single or multiconductor cables, are usually installed in conduit. Multi-conductor cables may also be installed in racks or trays.

The preferred multi-conductor control cable design is made with oil-base, ozone resistant rubber insulated conductors (Figure 13). A neoprene jacket is applied directly over the insulation on each conductor. This neoprene jacket is usually color coded for circuit identification. The conductors are cabled together with non-wicking, moisture resistant rubber fillers to provide a round cable core. A neoprene sheath is used for the outer, overall covering.

Steel mills use a large amount of direct current for both power and control purposes. There has been considerable difficulty with non-leaded wires and cables in d-c service. Failures often occur where the cables are subject to moisture. The dielectric characteristics of the insulation should be highly stable under wet conditions or direct current will accelerate osmotic diffusion or penetration of moisture. This phenomenon is sometimes called electro-endosmosis. Experience shows that insulation on non-leaded wires and cables for d-c service should be inherently moisture resisting. It should have a high degree of homogeneity and be free from coarse particles and contamination by foreign matter. Equally important, the insulation throughout the length of wire or cable should have no mechanical imperfections or manufacturing defects. Rigid testing of the insulated conductor by the manufacturer is necessary to assure the quality of insula-

Figure 13 — This multi-conductor, rubber-insulated, neoprene-shielded control cable has a neoprene sheath.

Figure 14 — Silicone rubber-insulated, aluminum-sheathed, control cable is used in high temperature applications.

tion and workmanship required for satisfactory d-c operation. Where leaded cables cannot be used, multiconductor cables with a moisture-resisting non-metallic jacket are desirable. Where single conductor cables are employed an extra $\frac{2}{64}$ in. thickness of insulation will improve operation on d-c circuits in wet locations.

Steel mills require wires and cables for use in many locations where high temperature conditions are found. Suitable wires and cables for these hot locations have been a problem. Asbestos and asbestos-varnished cambric insulated conductors are used, but their affinity for moisture is objectionable. Some steel mill electrical people would rather put up with rubber insulation baking out in a relatively short time than use the asbestos types. Insulations made with the new butyl rubber now available are considered superior in heat resistance to the older types of rubber insulated cables which work so well for general use in steel mills. Further experience with this type insulation may result in its expanded use in hot locations. The heat resistance of butyl rubber, however, is still not adequate for the higher temperatures encountered.

Silicone rubber insulated wires and cables provide excellent solution for the high temperature problem in steel mills. They possess all of the desirable features of the conventional rubber covered wires and cables including ease of handling and installing, moisture resistance and dielectric strength. Superior heat resistance or stability on long exposure to high temperatures is the outstanding characteristic of silicon rubber insulation. It is conservatively rated for continuous operation at 150 C (302 F) and will withstand temperatures as high as 260 C (500 F) without injury.

Silicone rubber insulated conductors have been furnished and used in increasing volume for about 10 years. The United States Navy uses extremely large quantities for shipboard cables. They are being used in industry for wiring around boilers, furnaces, ovens and numerous other hot places. Silicone rubber insulated wires and cables should be considered for use in steel mills for circuits exposed to high temperatures.

Silicone rubber insulated single conductors are furnished with a covering of glass fiber braid coated with silicone varnish. These conductors are suited for installation in conduit. They are also furnished in single conductor form or multi-conductor cable assemblies with various metallic outer coverings including a seamless aluminum sheath, a lead sheath, or interlocked armor.

The silicone rubber insulated cable with a seamless aluminum sheath should prove to be of particular interest for installation in locations in steel mills where high temperatures are encountered (Figure 14). It is impervious to moisture, oil and solvents. The aluminum sheath eliminates the need for conduit. It can be readily bent or shaped to pass through or around other objects and is held in place conveniently with galvanized iron or aluminum pipe clamps. The individual conductors are handled and terminated in the same manner as a conventional cable. No special fittings are needed. This cable should serve well, for example, for wiring on overhead cranes operating in hot places like the open hearth room and over the soaking pits. There are many power feeders to motors and control circuits subject to high temperatures for which the silicone rubber insulated, aluminum sheathed cable should be considered. It might be used to advantage for lighting in locations where heat destroys other kinds of insulated wire.

It is a pleasure to be able to report that progress in the art of insulated wire and cable manufacture has kept pace with the ever increasing requirements of the steel mills. There are available adequate and dependable insulated wires and cables for each specific need.

DISCUSSION

PRESENTED BY

C. L. SQUIER, Assistant to Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.

S. L. JAMESON, Electrical Engineer, Construction Engineering Div., General Electric Co., Schenectady, N. Y.

R. J. BEESWY, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.

JOHN HOGAN, Electrical Engineer, The Okonite Co., Passaic, N. J.

C. L. Squier: The newer cables are made more impervious to moisture, electrolysis, and other factors, which cause ultimate cable failure. However, some of the early types of cables are still in use and are still quite dependable. As an example, two years ago at the Lackawanna Plant of Bethlehem Steel, it became necessary to double the current-carrying capacity of several underground lines which were put in service in 1920. The original cables were 3-conductor, 500,000-cm, 15,000-volt ungrounded neutral, varnished cambric with lead sheath. The new cable which was to be paralleled with the old cable should have the same reactance to assure equal division of load on the cables. We specified the cable duplicate of cable installed in 1920, and several cable manufacturers quoted on the cable exactly as specified. You will agree that very few products "on the shelf" today, were available 34 years ago. It substantiates the fact that varnished cambric cable has a long standing reputation. The 1920 cable has gone through the years with few faults and the cable has car-

ried overloads for long periods. Some failures occurred on the cable before it became apparent that good grounding of the sheath was necessary. In the past six years only one failure has occurred, it was caused by a leak in a steam line which caused heating around the duct bank.

The success we have experienced with lead covered varnished cambric cable did not prevent us from installing rubber insulated "neoprene" sheathed cable on our most recent installations.

I would like to ask Mr. Hogan to briefly comment regarding his recommendations on "proof-testing" high voltage cables. As you know, many high voltage cables are installed and energized without first proof-testing.

S. L. Jameson: We agree that corrosion of the lead sheath has perhaps been the major problem in the use of lead covered cable. This trouble is practically eliminated by the use of neoprene hose jacket.

The author states that oil base ozone resistant compound rubber is preferred for 15-kv circuits. This is a fine insulation, but we prefer the use of a butyl base rubber with its greater ozone, moisture, and heat resistance properties. The use of this compound has increased a great deal in the last ten years.

We are in complete agreement with the use of 3-conductor cable for direct burial. An additional advantage in this type of cable is that ground wires may be included in the cable.

We feel that varnished cambric insulation is somewhat easier to handle in industrial practice than is paper insulation in cables up to 15 kv. Furthermore, many varnished cambric and lead splices and terminations can be made with a clamping ring and stuffing box and are not as difficult as a lead wiped joint. We use a dry compound on the cambric and have found no risers around steel mills high enough to cause trouble with varnished cambric insulation.

The use of 15-kv aerial cable indoors may be satisfactory technically, but would probably be frowned on by many safety committees or insurance inspectors. For indoor circuits we therefore feel that interlocked armor cable is safer due to the mechanical protection afforded by the armor.

The use of interlocked armor cable for both overhead power distribution and for heavy power circuits within motor room has been increasing very rapidly in the past few years. Cost analysis will frequently show varnished cambric insulation to be less expensive than rubber insulation for such cable. Potheads are not required for termination up to 15 kv indoors. The normal practice for steel mill use where extreme reliability is required is to specify a dry varnished cambric insulation with a polyvinylchloride hose jacket over the insulation and an interlocked armor cable overall. This cable is giving excellent service for overhead feeders and for risers from switchgear to the roof trusses in circuits up to 15 kv a-c and for d-c feeders.

Interlocked armor has been predominantly made of galvanized steel with bronze and, more recently, aluminum for corrosive conditions and outdoor installations. Corrosion resistance of galvanized steel armor can now be insured practically 100 per cent by the use of a light, tough and relatively inexpensive wall of polyvinyl chloride over the armor. An additional very attractive use of this coating over the armor, particularly in those plants where there are large amounts of overhead distribution at various voltages, is the use of bright colors for voltage identification. For example, on one present installation we are using a bright red jacket for identification of voltages over 5 kv, a blue jacket for identification of a-c voltages under 5 kv, and a green jacket for direct current circuits.

Interlocked armor cable offers a very attractive solution to the distribution of direct-current power within a motor room, or for risers from the switchgear to the roof trusses for overhead feeders, and for crane feeders. In this application we specify a 4-conductor cable paralleling two conductors for the positive and two conductors for the negative. This gives a much better utilization of the copper and a smaller overall diameter for equivalent current carrying capacities than would the use of a 2-conductor cable.

The use of 4-conductor interlocked armor cable on racks for main drive circuits may frequently be less expensive than the open bus copper normally used, especially for long runs. Cable is particularly attractive where space is limited and there is the additional factor of safety to personnel in operating areas or where headroom is limited.

We feel that rubber insulated cables in the 2000 to 5000-v class should be shielded. The IPCEA recommendations are that rubber insulated power cables in conduit for circuit voltages over 3000 v should be shielded. Experience has shown that no matter which manufacturer's cable is used, non-shielded cable at the 5000-v level will give trouble in about 5 or 6 per cent of the cases. Thus the use of non-shielded cable at these voltages involves a risk that should be recognized before it is accepted. The points brought out in regard to rubber and neoprene multi-conductor control cable apply equally well to properly manufactured polyvinylchloride cable. The polyvinylchloride has a further advantage of lower cost, greater chemical resistance and smaller outside diameter.

R. J. Beeswy: At Inland our practice is to put feeders and tie lines overhead, there being only a very few underground installations. Our experience has been that an underground installation does not permit easy relocation to conform with plant changes, a drainage method is required, and the addition of lines for plant growth when all ducts are filled is a problem. We will admit, however, that towers loaded with cables are not a thing of beauty.

We have adopted a tower for overhead lines that has a platform eight feet below the bottom cross arm. From this platform ladders on each side lead to the top of the tower. This allows the clearing of all lines on one side for inspection, repair or addition of new lines while reduced power is carried through the lines on the other half of the tower. An additional cost reduction is also made through the use of weatherproof cable with its higher carrying capacity. As protection, long cable runs are anchored or dead ended several places even in straight runs. Bare copper ground wire or wires are placed over all outdoor power lines with never more

than a 30-deg angle from the ground wire to the outside cables on a tower. Ground rods are driven at each tower and lightning arresters are used extensively. Our outages due to line faults are practically nil. Those that do occur are caused by contaminated atmosphere, smoke, dust, etc. These are held to a minimum by regular inspections and cleanings.

John Hogan: With regard to Mr. Squier's suggestion that we discuss recommendations for proof-testing, I would say that we consider this to be good practice on new construction jobs before placing the cable in service. It accomplishes several things. It checks the workmanship on splices and terminations and the workmanship on the installation generally, particularly as regards mechanical damage of the cables during installation handling.

In the case of, say, a steel mill or some similar client, having an electrical job done by an outside contractor, a proof test of the work before taking over the job from the contractor pretty much establishes whether or not any subsequent difficulty or any operating difficulties are due to the characteristics of the system or some design weakness or fault in the workmanship.

Also proof testing will detect faults without burning them out completely, so it is very commonly possible to analyze and examine the fault and determine what the cause of the fault was, whereas if the faults result from a power breakdown, the evidence is pretty much burned away and you never can positively determine the initial cause of the failure.

Also Mr. Squier mentioned that his cables that were 20 and 25 years old are still operating. We are thinking somewhat along the same lines, that we do not like to discard previously successful and satisfactory practices, which is one of our reasons for adhering to and continuing to recommend the use of oil-base insulation as our premium and best grade of high voltage rubber insulation, rather than butyl rubber insulation. We are well aware that the butyl rubber from a test standpoint has excellent ozone resistance and also heat resistance, but, on the other hand, we are also aware of installations where difficulty has been experienced, one of which is documented I believe in the November 1953 Electrical Engineering Magazine. It concerns a 15,000-v self-supporting butyl insulated, shielded, neoprene sheathed cable, on which the customer had considerable difficulty to the extent that the cable manufacturer finally replaced all the cables, amounting to some 20,000 or 30,000 feet of three conductor cable. The reason given by the manufacturer for the difficulty was that the butyl was corona cutting because of static discharge, and the replacement cable included a semi-conducting tape over the butyl insulation underneath the tinned copper shielding tape. It would seem that if the butyl had the degree of ozone resistance as indicated by tests and some manufacturer's claims, that this semi-conducting tape over the butyl insulation would not be necessary.

In the case of oil-base insulated cables, these cables have been made for 25 or more years without the necessity of a semi-conducting tape over the insulation under the metal shielding tape, and have worked with excellent results. So while we do not want to disregard the possibilities for the future of butyl installation, we also feel that it is not to be jumped into as being the solution to all problems.

With regard to Mr. Jameson's comments regarding interlocked armor cables, we generally are in agreement with them except that we are somewhat inclined to be a little conservative in recommending the interlocked armor cables as a solution for all problems. When you consider that the interlock metal tape that is applied to these cables is generally approximately $\frac{1}{32}$ in. thick, we cannot consider that this is equivalent in mechanical strength to a conduit and cable installation where the conduit will be anywhere from $\frac{4}{32}$ to $\frac{8}{32}$ in. thick and have approximately four to eight times the mechanical strength of interlocked armor for protective covering.

Also, in connection with interlocked armor cable, we know of a very large installation of this type cable on an outdoor pole line which has not been entirely satisfactory, and that customer's experience has been that he gets something in the vicinity of five to seven years' life from the cable.

When I speak of a large installation, I am talking of a plant that generates approximately 200,000 kva and distributes it all at 15 kv over interlocked armor cables, and they have, on occasion, purchased as much as a quarter of a million dollars' worth of interlocked armor cable simply for replacement of their original installation which was put in during the wartime.

So while we think that interlocked armor cables have a place, we do not think they will solve all the problems that exist or that they are necessarily the best type of installation for all jobs.

In regard to shielding for 5 kv, Mr. Jameson indicated that his records indicated that approximately five to six per cent of the non-shielded cable would be likely to give trouble. I do not recall now whether you mentioned any specific period of time or not, but it was felt that the risk should be considered and calculated if you decided to use non-shielded cable. Possibly that is true, but, on the other hand, there is considerable risk in using a shielded cable for a similar application. Possibly from the cable operating standpoint alone, the shielded cable would be advantageous, but from an installation standpoint the shielded cable possibly might lead to much more than the five or six per cent of trouble that your records show is experienced with the non-shielded cable. Due to the splicing and terminating problem, our experience shows that there is much more difficulty and greater cost with the shielded cable than with non-shielded cable.

In regard to Mr. Beeswy's comments, we recognize that overhead lines with overhead pole line construction and weatherproof wire is cheaper than insulated cable installation, but we also feel that most steel mill operators, where the economics of the situation justify it, would a whole lot rather have an insulated cable installation than a weatherproof wire installation.

That question is largely a matter of the economics of the situation and also the engineer's personal preference, so that you cannot disregard weatherproof wire because there is probably more weatherproof wire on pole lines used than any other installation.

By G. A. KAUFMAN
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Electrification of J & L's 44-in. Blooming Mill at Aliquippa

. . . . this paper was presented at the Pittsburgh Section Meeting of the AIEE on January 17, 1955. . . .

▲ ON September 8, 1953, after 41 years of service, the record-holding steam engine driving the Jones & Laughlin Steel Corp.'s 44-in. blooming mill at Aliquippa plant was retired. Seven days later a new 12,000-hp motor drive went into operation and normal production resumed immediately.

During the first full turn after the motor drive was placed into service on September 15, the number of ingots rolled equaled the normal average of the engine driven mill. Within six weeks, new records were made in the tonnage output for a 24-hour day. By the middle of November, the number of ingots as well as the tonnage record for 24 hours was broken. Before Christmas the number of ingots per 8-hour turn had been bettered. Then on January 3, after only 3½ months of service on one single turn of 8 hours, a new record was established in both the number of ingots rolled and tonnage produced. Some 576 ingots were rolled during this 8-hr turn — better than 10 per cent above the steam engine record of 522 established in 1949. The figures are given in Table I.

Records are made to be broken. It is not unusual for a new mill to set new records. It is expected. It was expected on this mill. Most everyone connected with the project was well aware of the fact, however, that to just match the performance of the old steam engine, could in itself be quite a task. This old engine driven mill held the world's record for small ingots.

With regard to the performance requirements, the equipment specifications said as follows: "The electric drive for the Aliquippa blooming mill must equal or surpass the performance of the present steam engine." This requirement presented a real challenge to the electrical equipment designers.

The engine could accelerate or reverse without steel in the mill at the rate of 98 rpm per second. The new drive can reverse at rates of 140 rpm per second — even higher if necessary. This is at least 40 per cent faster than the steam engine. It has much more momentary torque capacity than the steam engine had. The potential output of this drive is considerably above that of the old engine.

However, how was such a change-over to electric drive justified economically without assurance of a substantial increase in mill output? The specifications would have been satisfied by simply equaling the previous performance.

There are simple economic reasons, in themselves adequate to justify electrification. It costs more to operate and to maintain a steam engine than it does to operate and maintain an electric drive. A detailed cost analysis made by J & L's Industrial Engineers a few years ago showed that net savings of approximately $1.25 per bloom could be realized through electrification of the blooming mill. Calculated savings based on some 1,600,000 bloom tons produced that particular year exceeded $2,000,000. The following are some of the items which go to make up this figure.

1. Annual savings in maintenance have conservatively been estimated at $500,000 with an incidental five per cent increase in mill availability as a result of less maintenance downtime.
2. The largest savings are in power consumption. They are tremendous — primarily because the engine losses were so high. As a good measure of

TABLE I

Record 8-Hour Run — January 3, 1954

576 ingots	8 hr
76 ingots	maximum for 1 hr
72 ingots	average for 1 hr
2797 ingot tons	8 hr; 350 tons per hr
2543 net tons of sheared blooms	8 hr; 318 net tons per hr
Yield	91 per cent
Ingot size: 22 x 24 in.	9720 lb
Bloom size: 8 x 8 in.	

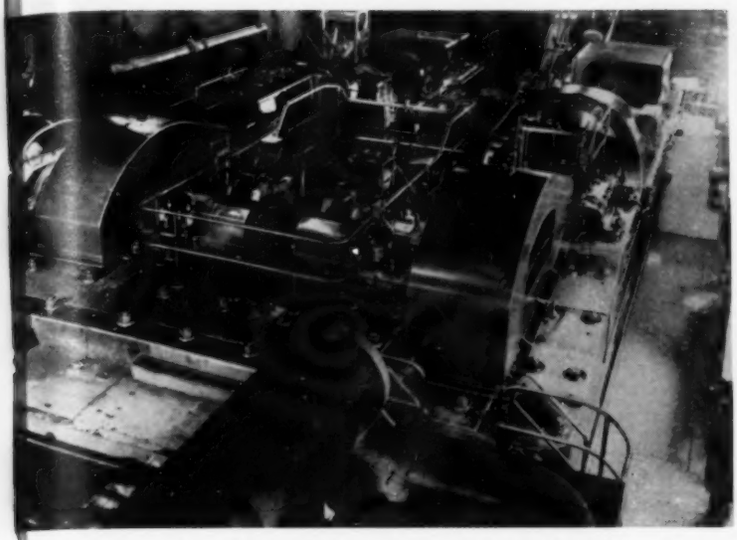


Figure 1 — Steam engine shown driving the 44-in. blooming mill was retired September 1953.

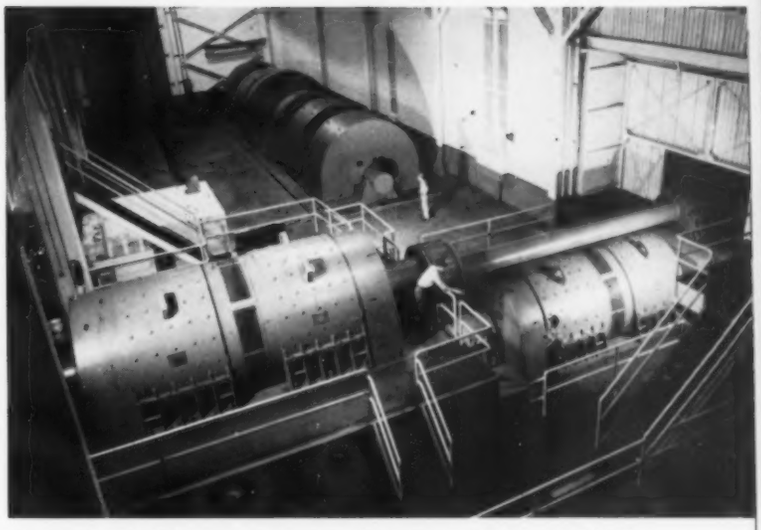


Figure 2 — Motor room shows the new 12,000-hp, 70/140-rpm, 750-volt, double-armature twin-drive motor in the foreground and the 12,000-kw, flywheel motor-generator set in the background.

these savings, steam which would formerly have gone to the engine is now available to the 25,000-kva turbo-generator heretofore lightly loaded. Today, with no change in the quantity of available steam, the round-the-clock average output of the turbine has been increased by about 18,000 kw. The main drive motor-generator set takes between 2500 to 3000 average kw, which when deducted, leaves at least 15,000-kw net increase. In 24 hours, this adds up to 360,000 kwhr reclaimed every day on the average. Thus the average amount of electrical energy which J & L must purchase every day has been reduced by at least 360,000 kwhr. If evaluated at one cent per kwhr, power savings to J & L for a normal operating year amount to at least $1,250,000.

Furthermore, the engine was almost worn out. The bedplate was cracked, bearing alinement was impaired. Maintenance was very high. Therefore, since the entire output of the Aliquippa Plant depends on this mill, the engine was no longer considered reliable.

These are the real reasons why J & L engineers have for years been planning to convert to electric drive. When the opportunity finally came they knew exactly what to do in planning the whole program to require a record minimum shutdown time of the mill.

In Figure 1 there is a picture of the old steam engine installation. It is a view looking south, with the mill outside the left wall.

Figure 2 is a picture of the new installation. The 12,000-hp double-armature, twin drive motor is in the foreground; and the 12,000-kw, motor-generator set in the background.

Figure 3 is a section drawing of the mill and motor room looking north and in Figure 4 there is a motor room section looking south. A full length bay at one side and one-half bay at one end are new. They were constructed to house nearly all of the electrical equipment except the main drive motor and the motor-generator set. This additional space provided the necessary elbow room to get the conversion under way.

The section (Figure 4) shows among other things, some ventilating system details. It will be noted for instance that the air from the bottom of the motor-generator set moves to the right through the surface air coolers then through the air filter and next through the up-blast fans to the motor room upstairs. The ventilation of the motors is carried out in a similar manner, namely the air is drawn downward through the machines, through the surface air coolers, through the air filter and then returned to the main room by the recirculating fans.

In the balcony of the new bay are the main exciter sets, the adjustable voltage control auxiliary motor-generator sets, the rotating regulator sets and the 250-volt battery. The auxiliary control panels are located on a separate balcony on the opposite side of the room adjacent to the mill.

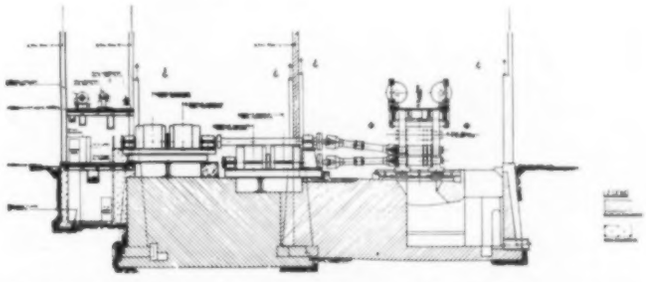


Figure 3 — Section drawing of mill and motor room looking north.

Figure 4 — Section drawing of motor room looking south.

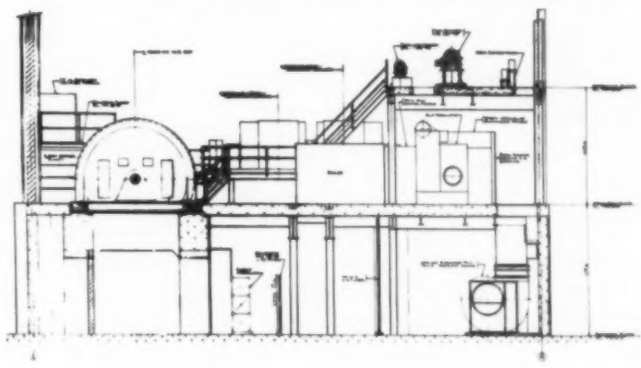


TABLE II

Ingot weight, lb	Ingot size, in.	Product size, in.	(Approx) Per cent of total product
9,000	22 x 24	8 x 8	50
9,000	22 x 24	$9\frac{3}{8}$ x 4	6
9,000	22 x 24	$11\frac{3}{8}$ x 4	6
9,000	22 x 24	15 x 4	6
10,000	24 x 24	7 x 7 8 x 8	5
10,000	24 x 24	10 x 10	18
10,000	24 x 24	$11\frac{1}{4}$ x $11\frac{1}{2}$ $11\frac{3}{4}$ x $11\frac{1}{2}$ 12 x 12 $12\frac{1}{4}$ x $12\frac{1}{4}$ $12\frac{1}{2}$ x $12\frac{1}{2}$	7
9,000	22 x 24	36-39 x $4\frac{1}{2}$	2

HOW WAS THE MOTOR RATING SELECTED?

First let us consider what J & L rolls on this mill by referring to a typical scheme, Table II. The preponderance of product is small sized blooms.

Extensive tests were made in 1941 and served as a guide to the selection of the motor rating. The average rolling speed at that time was found to be 69 rpm. The maximum recorded speed was 128 rpm. Safely matching these values, 70/140 rpm was selected as the proper speed for the motor.

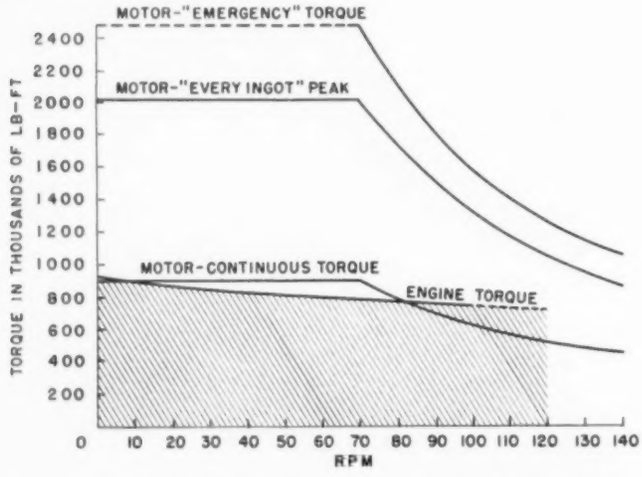


Figure 5 — Torque characteristics of motor and engine.

These tests also showed that the engine reversed the mill between passes at a rate of change in speed of 98 rpm per second. Therefore, 100 rpm per second was established as the absolute minimum rate that would be acceptable for the motor drive. While this did not appear difficult, it nevertheless suggested that low WK^2 was important. Four-armature construction offers advantages over two armatures in this respect and was therefore adopted.

The tests, together with these factors resulted in the decision to use a 12,000-hp, 70/140-rpm, 750-volt, d-c, mill type reversing motor, consisting of four 3000-hp armatures arranged as a double armature twin drive unit, with the two armatures (totaling 6000 hp) in mechanical tandem, driving the top roll and the same for the bottom roll. This rating was chosen only after analyzing the performance on the heaviest rolling schedules of all sizes of blooms, and also after giving some thought to future slab rolling requirements. Preliminary analysis indicated that speed changes during reversal even as high as 140 rpm per second were possible with good generator characteristics, properly selected exciters and a good control system.

Some people are under the impression that the WK^2 of a steam engine is less than that of a motor. Exactly the opposite was found to be true in this case. The total WK^2 of the engine drive plus mill was 2,370,000 lb-ft.^{2} whereas the motor plus mill WK^2 totaled only 1,725,000, a reduction in total WK^2 of 27 per cent.

The old engine torque was much lower than that of the motor, as can be seen by the characteristic curves (Figure 5). It explains, among other things, why the operating practice has always been to accelerate the mill to a high speed before entering the steel. Obviously, the engine did not have enough torque to handle a substantial rolling load while accelerating. On the heavier passes, the mill would actually slow down as the rotational energy supplied some of the rolling power. When rolling light sections, this practice of reversing and entering on the fly would result in a high average rolling speed. The new drive on the other hand has plenty of torque to enter material and accelerate at most any speed.

MAIN DRIVE MOTOR FEATURES

Fabricated steel bases and pedestals were specially designed as necessary to use the present engine foundations with the least modifications, even to the extent of using some of the existing foundation bolt holes.

Flange type couplings were forged integral with the motor shafts, thus saving in overall length and reducing the WK^2 of the rotating parts.

The stator frames are suitably laminated to insure successful commutation under the severe transients applied to these motors.

THE MAIN MOTOR-GENERATOR SET

Main drive d-c power is supplied by the 6-unit, 7-bearing, 360-rpm, motor-generator set. Each of the four generators is rated 3000 kw, 750 volts. The flywheel has 250,000 hp sec stored energy at 360 rpm and the wound rotor induction motor is rated 9000 hp, 6600 volts, 3 phase, 60 cycles. The generators can deliver a maximum of 275 per cent of rated full load current at rated 750 volts even with 15 per cent motor slip where the speed of the set is only 306 rpm.

The generator magnet frames are laminated to provide high shunt field response, and to aid in keeping commutating field flux in phase with the armature current.

All the generators are exact duplicates mechanically and electrically — except two of the stators are connected for opposite rotation. The armatures are interchangeable.

Sufficient clearance is provided at each end of the set to permit removal of any inside generator by simply shifting the outside machine endwise to clear the rabbet fit at the coupling. A dummy shaft is provided to operate with either inboard generator thus removed.

The main drive armature circuit is shown in Figure 6. The connection as shown, with links open, is the normal

one and provides two separate armature loops. This keeps the short circuit level lower than it would be with all generators tied together. If however, one generator should be out of service for repairs the remaining three are connected to a common bus, by means of the connecting links and can still supply the motors with practically no reduction in mill output.

A unique feature of this circuit is the arrangement for generator load balance. Each generator has a differential and a cumulative series field. The common point on each generator between these fields is connected together by

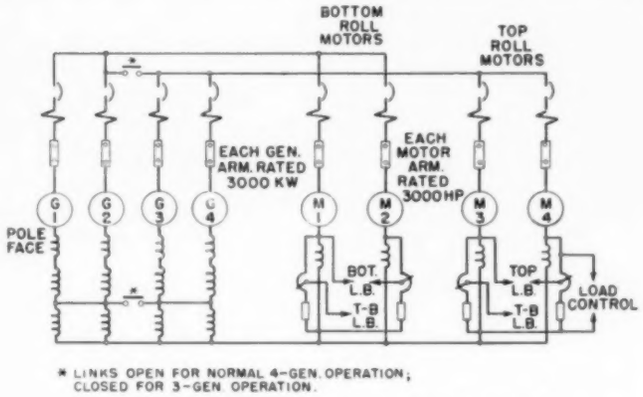


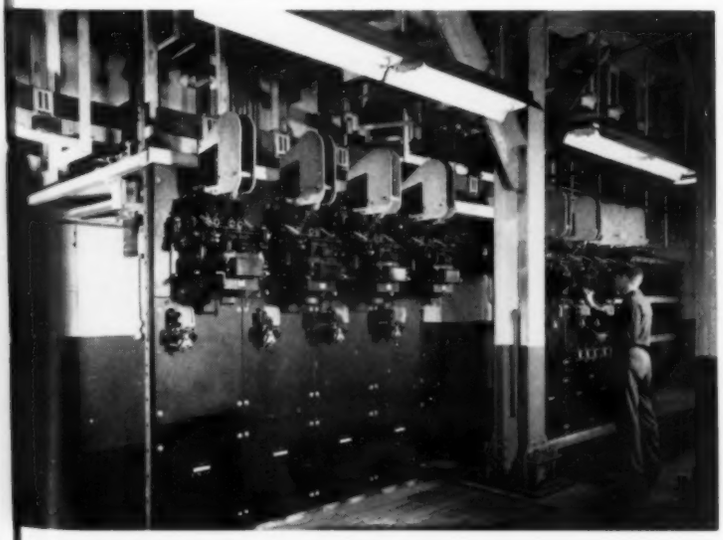
Figure 6 — Main drive armature circuit.

an equalizer connection. The differential field is the one adjacent to its respective armature, and this makes each generator voltage regulation drooping to obtain the proper division of load. Because of the equalizer connection the cumulative series fields act collectively to correct the droop. This arrangement has the advantage over the common cross-connected series field method in that it is simpler to install and with it, it is easier to remove one generator from service. No supplementary generator load balance regulators are required.

The auxiliary connections shown around the commutating and compensating fields of the motor armatures pertain to the balancing of the loads between the four motor armatures and will be discussed later.

The eight 6000-amp circuit breakers are shown mounted on the panels, (Figure 7) in the basement. The

Figure 7 — Eight 6000-amp armature circuit breakers are panel-mounted in the basement.



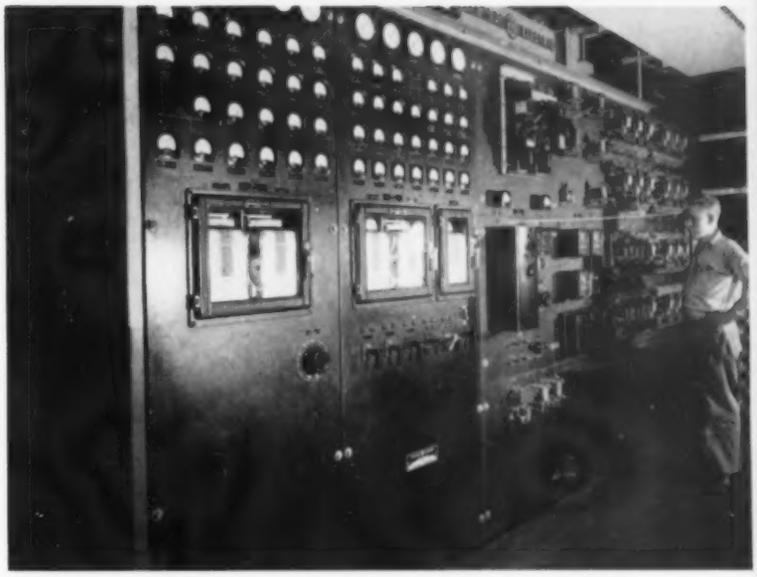


Figure 8 — Main drive motor and generator field control panels.

primary purpose of these is to protect the machines against excessive overloads, armature circuit short circuits, and to minimize damage in case of commutator flashovers. Normally, they are closed when the operators take their place in the pulpit; and not opened until they leave the pulpit — or stop rolling for a while.

MOTOR AND GENERATOR FIELD CONTROLS

The starting, running and reversing of the mill is all done by generator and motor field control.

Figure 8 is a front view of the field control panel, with relays on the right; indicating instruments, recorders and control switches on the left. Instruments are included in all the regulating field circuits.

We might ask the question: What is the most important function of the control system? By far the most important function of the control is the rapid reversal of the mill within safe commutating limits of the machines. In order to get the most torque per ampere out of the motors, for fast response, the accelerations and reversals within plus and minus 70 rpm are by armature voltage and full motor field. Motor field weakening is used above 70 rpm.

Mechanical inertia on this mill presents no problem in base speed to base speed reversals. Currents averaging less than 100 per cent will reverse the mill from 70 rpm to 70 rpm in one second. Such base to base speed reversals are essentially nothing more than a matter of reversing the voltage at a reasonably uniform rate. The motor speed simply follows the voltage. In Figure 9 there is a record of two such reversals. The average value of currents shown for a reversal is about 75 per cent of the rated 3250 amperes per motor armature. The complete reversal from 70 rpm to 70 rpm is accomplished in slightly less than one second or at a rate of about 150 rpm per second.

Reversals from the higher speeds where the motor fields are weakened present control problems — for the reason that rotational stored energy increases as the square of the speed, while available motor torque drops off with increased speed. At 140 rpm for example, the

motor can safely commutate only 85 per cent as much current and develop only 42½ per cent as much torque as at 70 rpm. Such practical considerations force the acceptance of lower reversal rates on drives whenever field weakening is introduced. Figure 10 is a record of motor current and speed when reversing from 125 rpm to 125 rpm. The reversal time is 2.25 seconds. The reversal current peak is limited to the value shown by a pumpback control circuit which retards the rate of voltage decay when regenerative motor current exceeds some specified value.

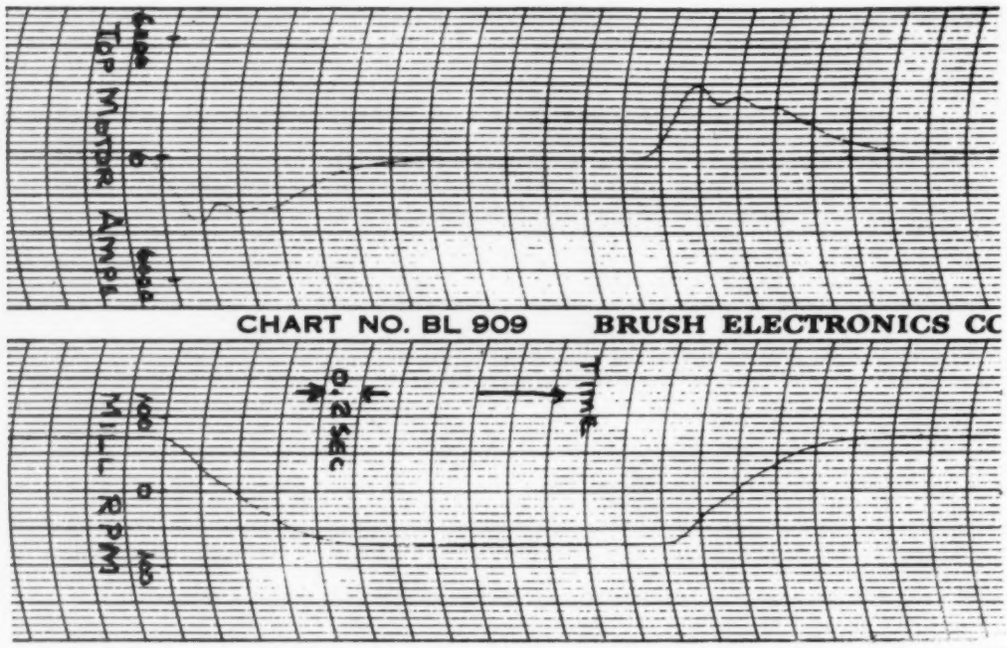


Figure 9 — Motor amperes and rpm are given when reversing from base speed to base speed.

All four generator fields are supplied in parallel by a single exciter as shown on the sketch (Figure 11).

A simplified version of the generator field control is shown in Figure 12. The circuit is drawn on the basis of one generator armature and one motor armature. A generator exciter (GE) receives its excitation from the generator voltage control exciter (GVCE). The latter is a rotating regulator and does the actual voltage regulating. In the generator voltage feedback loop there is voltage pilot (VP) which sets up the operating voltages corresponding to the master switch positions. Since the polarity of the voltage pilot opposes the generator feed back, the voltage pilot provides forcing during accelerations and reversals. Besides some additional forcing is obtained since the (GVCE) rotating regulator is given some basic excitation through its bias field, likewise under the control of the master switch.

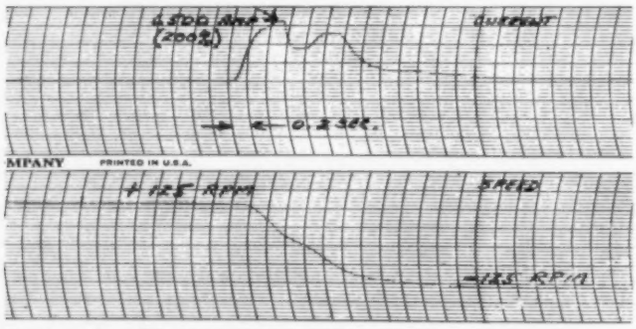


Figure 10 — Motor amperes and rpm are given when reversing from 125 to 125 rpm.

The lower part of Figure 12 is the "pumpback" circuit. Upon rapid reversals, from the higher motor-weak-field speeds the pumpback control steps in to slow down generator voltage decay while the motor field is building up. Since the commutating ability of the motor drops off with field weakening, the pumpback magnetic amplifier is biased as a function of motor field strength.

Responsive drives such as this simply cannot be built without excitation systems capable of producing out-

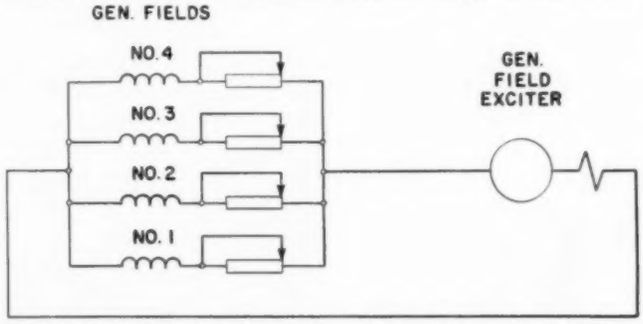
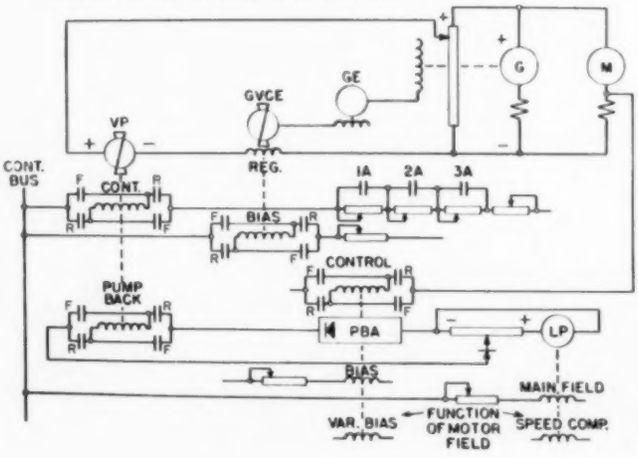


Figure 11 — Schematic diagram shows how the fields of the four 3000-kw generators are supplied by a single exciter.

Figure 12 — Simplified schematic diagram shows basic system of generator field control.



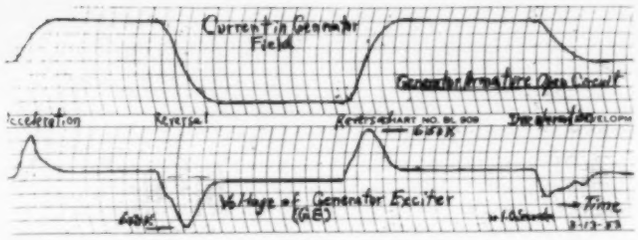


Figure 13 — Generator field current and generator exciter volts during two base-to-base speed reversals.

put voltages during transient conditions, many times the steady state requirements. Intensive forcing may tend to introduce instability and proper precautions must therefore be taken. Figure 13 is a graphic record of generator exciter volts and generator field current. Peak voltages of the exciter are seen to be about 9½ times the steady state values. This, incidentally, checks calculations quite well. The steady state hot drop through the field is 68 volts. Peak voltages here are about 650. The exciters are actually rated 700 peak volts.

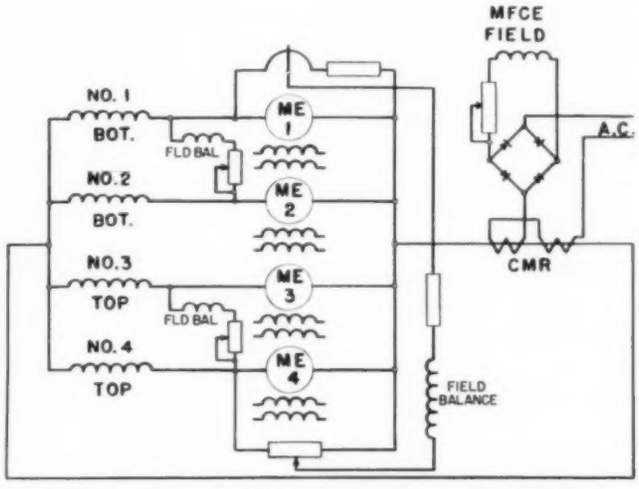


Figure 14 — Simplified diagram of motor field circuit.

Next to be considered is the motor field control system. By referring to the Figure 14 it will be noted:

1. That each motor field has its own exciter.
2. That a current measuring reactor CMR is used to measure total current.
3. That each exciter has a main and an auxiliary field.
4. That load balance is made part of the motor control field circuits — these will be discussed later in detail.

The sketch (Figure 15) is a simplified schematic diagram of the basic motor field control. The motor exciter (ME) receives its excitation from (MFCE), which is a rotating regulator and which does the regulating of motor field current. The (MFCE) reference is supplied by the amplistat (MFP), the output of which is determined by the master switch control, point 6A. The motor field current feedback signal to the exciter (MFCE) is supplied through the rectified output of the current measuring reactor (CMR).

In view of the rolling practice of entering the material at or near base speed, the current limit field will, if necessary, function to prevent field weakening and actually try to strengthen the existing full field. In other words, it will prevent the mill from accelerating on weak field under high load conditions, even if the operator moves his master switch to the top speed point.

The load pilot (MLP) provides a bias voltage which must be overcome by the IR drop across the motor commutating and compensating fields before the current limiting circuit steps in.

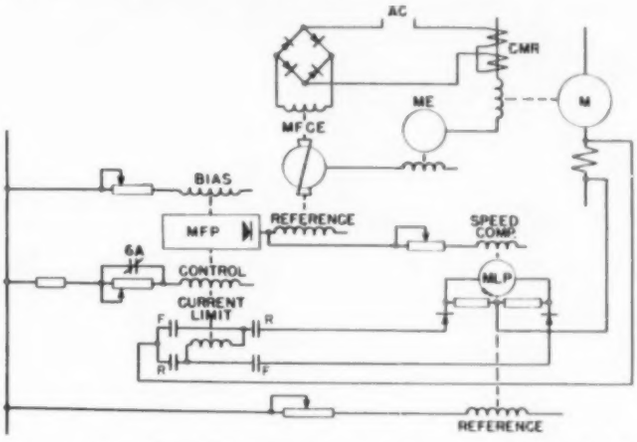


Figure 15 — Simplified schematic diagram shows basic system of motor field control.

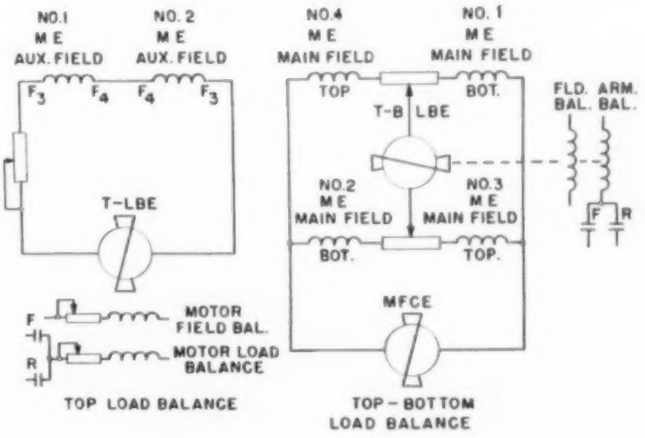
LOAD BALANCE

The two armatures driving the top roll must share the load equally; likewise the bottom ones. In addition to this, proper load sharing between the top and bottom motors must be assured. This is all done by comparing voltage drops across the respective motor commutating and compensating fields and working into load balancing exciter circuits.

Load balance between armatures on a single shaft is accomplished by the circuit shown at the left of Figure 16. The load balancing exciters LBE-T and LBE-B are working through the medium of auxiliary fields on the motor field exciters. Depending upon the direction of unbalance, the load balancing exciter will buck and boost or boost and buck the respective motor exciter auxiliary fields.

Balance between the top and bottom rolls is regulated by the circuit shown at the right hand side of the same Figure 16. In this case the load balancing exciter LBE-TB is connected between the mid-points of a

Figure 16 — Motor armature load balance circuits.



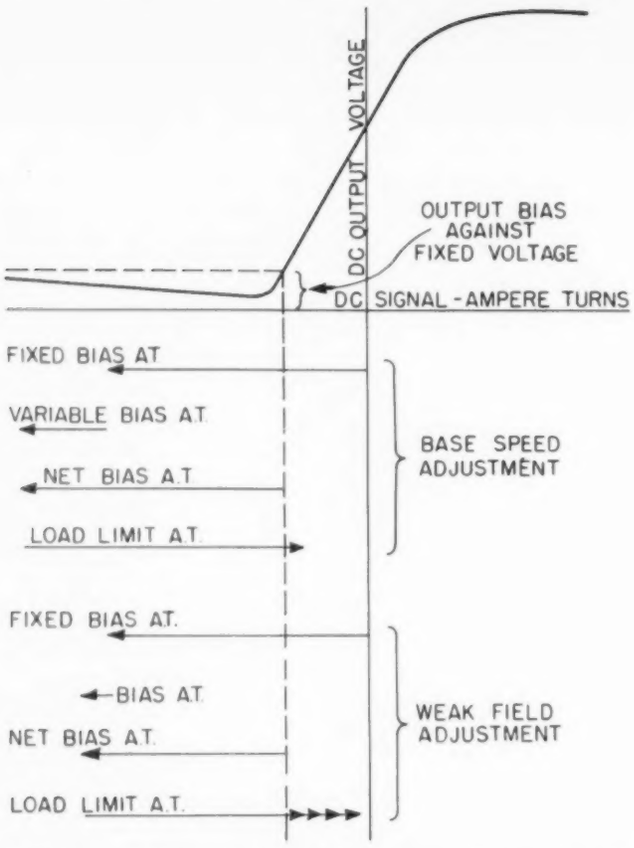
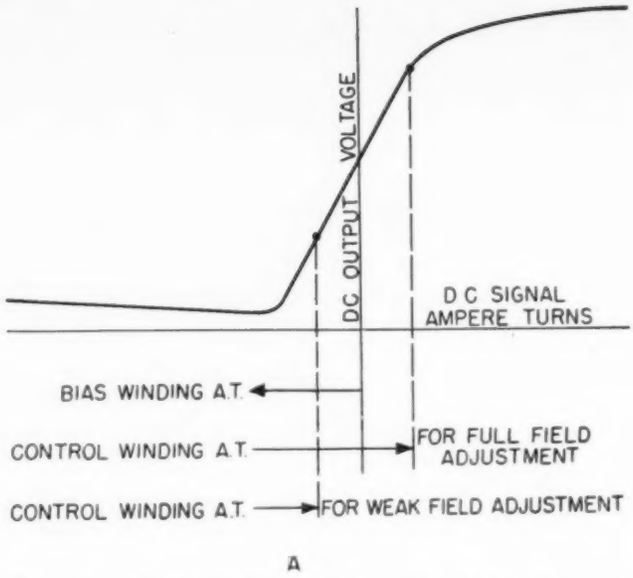


Figure 17 — Characteristics of the pumpback magnetic amplifier.



A

Figure 18 — Characteristics of the motor field pilot magnetic amplifier.

bridge circuit formed by the main fields of the motor exciters 1ME, 2ME, 3ME and 4ME. Likewise, depending upon the direction of the unbalance, the load balancing exciter will boost the excitation on one set of exciters while it simultaneously bucks the excitation on the other set of exciters.

It should be noted that there are two control fields on the load balance rotating regulators. One is the motor field current balancing field which gives equal top and bottom roll speeds when running light. Under load, however, the armature current balancing field will dominate. It is not always necessary that the loads be equal between top and bottom motors. Adjustment is provided to make one motor assume more or less load than the other if the mill is found to roll better in this way. Either the top or the bottom motor may be forced to take the load.

MAGNETIC AMPLIFIERS

Very briefly, it can be said that in regulating circuits involving reversals and requiring considerable power, the rotating regulator does a job which is difficult to match in any other way. Magnetic amplifiers are inherently nonreversing, although they can be applied to reversing jobs with some attendant circuit complications and additional equipment. This subject is brought up here because it may already have been noticed that two magnetic amplifiers are used in the controls, the one as a pumpback amplifier and the other as a motor field pilot.

The ones used are rated forty volt amperes. They are small, easy to mount, and do their assigned job very well. A look at the characteristics shown in Figure 17, as applied in the pumpback amplifier, will explain why this is so.

It can be seen at a glance how a magnetic amplifier might be a "natural" for any spill over circuit. The amount of bias determines what value of pumpback ampere turns will make the amplifier operate. At weak field the variable bias is reduced as a function of motor field current, and a lower value of pumpback ampere turns will trigger the magnetic amplifier.

Perhaps an even more interesting application is the motor field pilot shown in Figure 18 which provides a reference to which the motor field current is regulated. Here the amplifier is first biased to the cut-off point. This is then countered by excitation in the opposite direction to turn the amplifier on. The degree that the unit will conduct and will supply current to the reference field of the rotating regulator (MFCE) is governed by the amount of excitation in the turned on direction.

An inherent characteristic of the magnetic amplifier is to saturate abruptly. This can be seen by the rather sharp break in the output curve. It is a desirable characteristic in this application since it prevents over-excitation of the motors.

The lower curve in Figure 18 shows another characteristic which is peculiarly useful here. This is a volts output versus time characteristic following application and removal of a fixed signal. It shows that the magnetic amplifier responds more slowly in the turned-off direction than it does in the turned-on direction. This means that when changing from full field to weak field, to accelerate the motor, the field gradually approaches it's final value. This is ideal since it reduces the tendency for overshooting of motor speed. The higher rate of response in the field strengthening direction is also advantageous. It aids in quickly restoring motor torque when decelerating from high speed, as well as increasing the response from the load limit control.

AUXILIARIES

More time is actually spent handling the material outside the mill than in the mill. In order to produce

most effectively, the tables, manipulators and screwdowns must be properly coordinated with the mill in speed and responsiveness.

Adjustable voltage drive equipments were therefore purchased for the screwdowns, feed rolls and live tables.

Some old and some new motors were used. All of them, of course, are the mill auxiliary type designed to withstand severe mechanical abuse and heavy overloads. By adding forced ventilation, the nameplate horsepower one-hour ratings become continuous ratings.

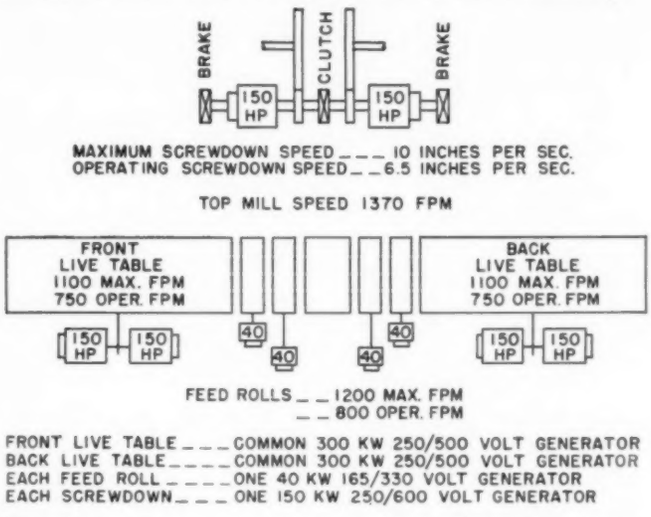

BRAKE
CLUTCH
BRAKE
150 HP
150 HP
MAXIMUM SCREWDOWN SPEED _ _ _ 10 INCHES PER SEC.
OPERATING SCREWDOWN SPEED _ _ 6.5 INCHES PER SEC.
TOP MILL SPEED 1370 FPM
FRONT LIVE TABLE 1100 MAX. FPM 750 OPER. FPM
BACK LIVE TABLE 1100 MAX. FPM 750 OPER. FPM
150 HP
150 HP
40
40
40
40
150 HP
150 HP
FEED ROLLS _ _ 1200 MAX. FPM
_ _ 800 OPER. FPM
FRONT LIVE TABLE _ _ _ COMMON 300 KW 250/500 VOLT GENERATOR
BACK LIVE TABLE _ _ _ _ COMMON 300 KW 250/500 VOLT GENERATOR
EACH FEED ROLL _ _ _ _ ONE 40 KW 165/330 VOLT GENERATOR
EACH SCREWDOWN _ _ _ ONE 150 KW 250/600 VOLT GENERATOR

Figure 19 — Plan of the mill shows the adjustable voltage auxiliary drives.

The motors can be operated at voltages as high as 600 with corresponding increase in horsepower. Double voltage 250/500 volt generators were selected for the tables, while generators with a voltage range 250/600 volts were used for the screwdown.

Table speeds are usually set to facilitate entry of the steel into the mill. It is however, important that the tables accelerate and reverse quickly; yet, even here there are practical limits to acceleration such as 600 or 700 fpm per sec, beyond which the metal simply slips on the table rolls and will not accelerate any faster regardless of what the table may be doing. Figure 19 is a sketch of the plan of the mill and shows the adjustable voltage drives. It will be noted that two speeds are indicated for each drive on this sketch. The ones labeled operating speeds were actually selected to satisfy the mill operators. Each drive therefore has considerable margin for higher speeds to be used if the occasion demands. It is doubtful however that the operating people will ever ask for any higher speeds on these auxiliaries.

OPERATION

There are three operators in the pulpit. The roller operates the screws, the live tables and feed rolls; the feed rolls being controlled by the table master switches. The second operator controls the manipulator fingers and side guards. The third man controls the main drive.

Steel is usually entered at about base mill speed (650 fpm). On the final passes the mill is then accelerated beyond this speed after steel is in the mill.

The conventional 6-point master switch is used although the fourth and fifth points are not connected. Points 1, 2 and 3 are set for 200 volts, 600 volts and

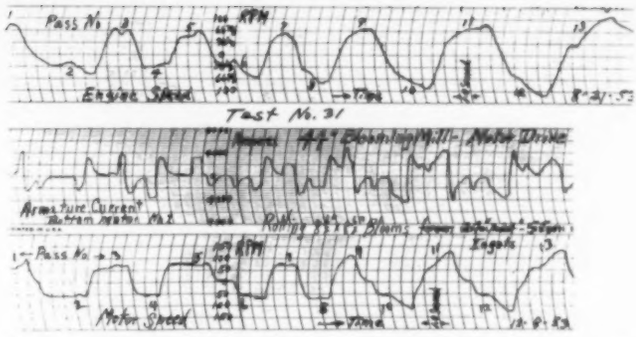


Figure 20 — Comparison of engine speed and motor speed is given for rolling the same product.

750 volts respectively. Points 4 and 5 are blank, leaving only point 6 for field weakening. This arrangement seems to make it easier for the operator to select good voltage points for entering, and he is less apt to touch motor field weakening unless it is really wanted.

The operating people, incidentally, feel quite confident that their system of using three operators holds definite advantages over two-man operation, wherever the highest production is so essential—as on this mill. Records are available to support this contention. Several detailed rolling analyses have been made by the J & L operating personnel through the years. One of these studies involved the use of a six-element oscillograph and a movie camera to simultaneously record all of the operations. While details on these studies are beyond the scope of this paper, the study did show that three good operators can achieve a degree of coordinated and split-second timing which two men simply cannot equal.

One direct comparison of the engine and motor when rolling the same product is given in Figure 20 where the upper trace shows the engine speed when rolling 8½ × 8½-in. blooms from 24 in. × 24 in., 5-ton ingots. The bottom curve was taken when rolling the same product with the electric drive from the same size ingot. In either case the operators were unaware that the records were being made. Chart length is a measure of time — showing 56 seconds for the engine and 50 seconds for the motor drive on this 13-pass schedule.

Bearing in mind that the charts' scales are different — 50 rpm per major division on the bottom and only 33⅓ rpm per major division on the top, it is seen that the average speed is higher for the motor because reversal rates are higher. The top speeds are also higher for the motor and there is a very noticeable ability on the part of the motor to maintain higher rates of acceleration in the upper range of speeds where the engine simply lays down.

SUMMARY

From the first time, many years ago, whenever electrification was discussed or thought about, there was this disturbing question: How can the mill possibly afford to stop production long enough to make the change? More people spent more hours, considering more plans or procedures on this than on any other problem. All this thinking paid off. The end results were nothing short of spectacular. What is now the main portion of the motor room was occupied by the engine, it's auxiliaries and hydraulic pumps. Arrangements

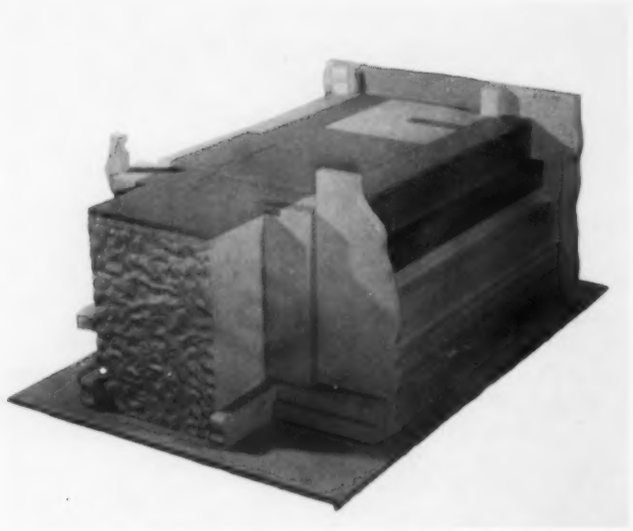


Figure 21 — Model of engine foundations was built to scale of ½ in. to foot.

were made to first move nearly everything out of the engine room except the engine itself. This permitted a lot of advance construction work, including installation of the main motor-generator set. A lean-to running full length of the building was added to house the bulk of the other new electrical equipment; except, of course, the main drive motors.

In order to study the problems of actually removing the engine, changing the foundations and setting the motors in place, a scale model of the steam engine foundation was built. Figure 21 is a picture of this model. It was assembled and disassembled piece by piece to study and demonstrate the individual steps which had to be taken to modify the present foundation before and after shutdown; and then to systematically complete the job to the point as shown on the picture, Figure 22. Needless to say, the model was extremely helpful.

Since the switchgear, motor-generator sets, exciter sets, control equipment and even the ventilating equipments were all installed early, about 95 per cent of the testing and electrical adjustments were made before the engine was shut down. This therefore resulted in reducing the time needed for such work during the last stages when the motor unit replaced the engine.

Months before this, however, the main and auxiliary drive control systems were studied by setting them up on a differential analyzer. Practically all of the operations were simulated. Performances of individual system components such as the regulating amplifiers, exciters, motors and generators were recorded on the oscillograph. Feedback control systems were adjusted on the computor to give the operating characteristics that the engineers and operators desired. With this information it was possible to determine the degree of forcing required and to make many advance adjustments in the control at the factory.

Figure 22 — Model is shown with motor installed.

The construction people did all that was possible before shutdown. They knew they would be "on the spot" the moment the engine was stopped. Every detail of the work was carefully scheduled and assigned. "Skull practice" meetings were held to be sure that everyone understood his job. An incentive schedule was set up.

All was in readiness that September 8 morning when the engine rolled its last bloom. Immediately hundreds of men swarmed all over the place. Shortly after that, the picture in Figure 23 was taken. The engine as shown was already well on the way to becoming history.

It was a race against time. Human interest took the stage demonstrating the remarkable power of good organization, good planning and high morale. Everyone worked hard and they worked together.

Exactly seven days, fourteen and one-half hours after the last ingot was rolled on the old mill, the first ingot (Figure 24) was rolled on the new mill. Immediately, the roller blew for a second ingot, then a third. Actually, 46 ingots were rolled during that first hour and normal production was under way.

The new drive has met or exceeded all expectations; and has been operating on regular schedule without interruption since that time.

Figure 23 — Engine is shown shortly after final shutdown.

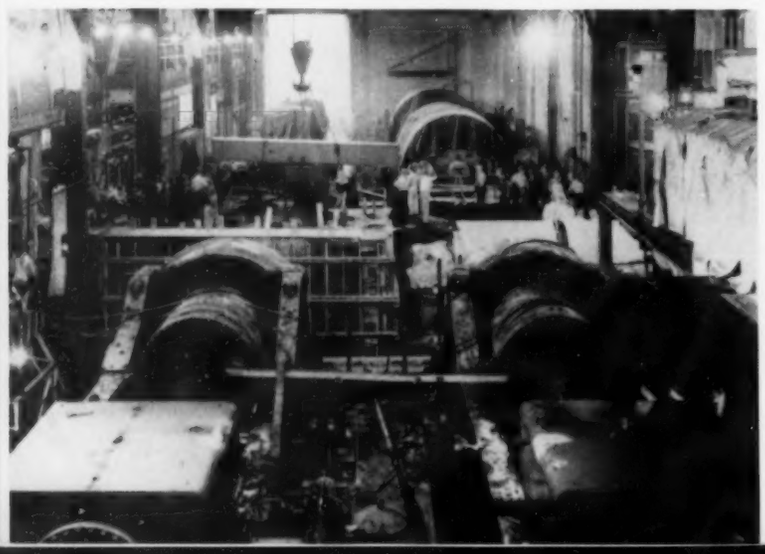
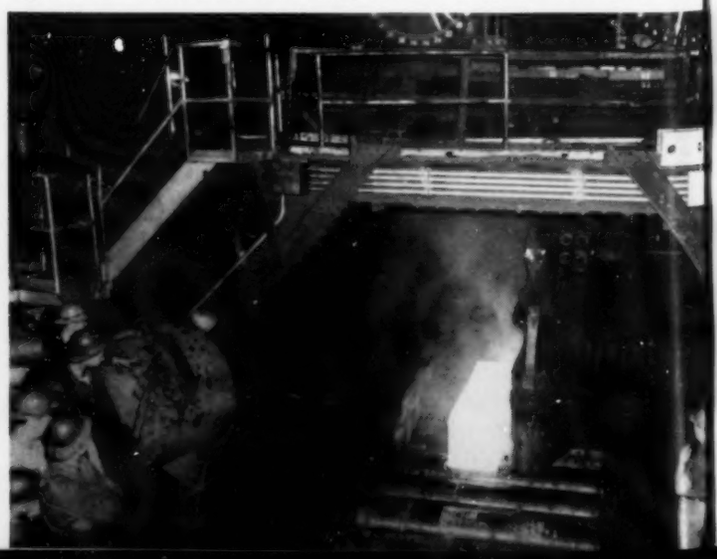


Figure 24 — View shows first ingot in mill after conversion.



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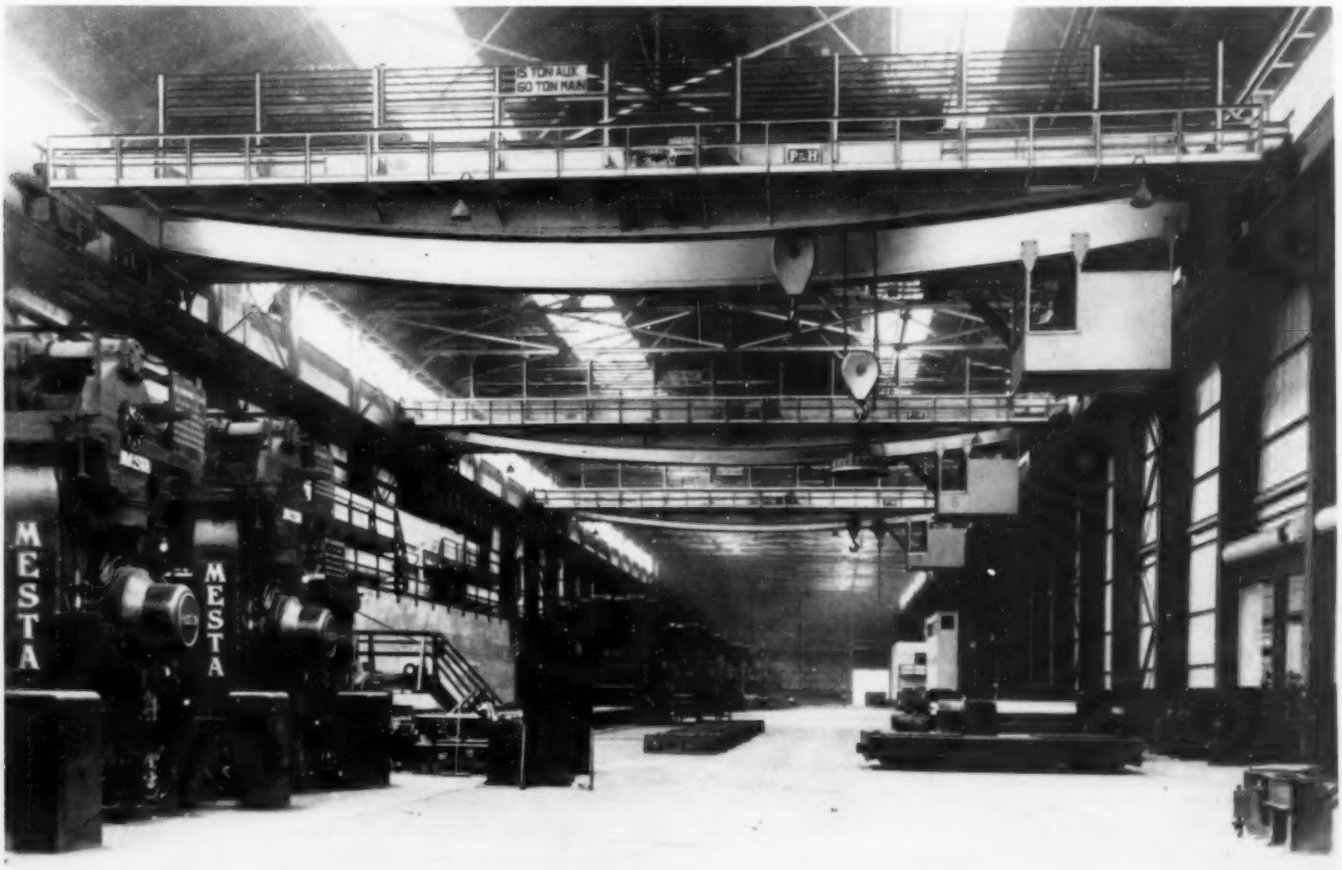
Overhead Crane Maintenance

. . . . for economical crane maintenance it is first necessary to keep the crane runway in shape; second, it is necessary to have correct power supply with adequate taps . . . . cranes also require constant inspection and lubrication with consequent adjustment of mechanical and electrical components . . . .

▲ EQUIPMENT maintenance has always been a controversial subject. With the growth of industry in recent years, and the introduction of more complex machinery, we can rightfully conclude that the upkeep of production facilities will give basis for even more controversy in the future.

For the most part, when someone brings up the subject of maintenance, we usually think of repairs and adjustments. This is normal, since in the past, the general trend was to allow equipment to function, regardless of the degree of efficiency, until it was broken down, then necessary repairs were made. The full time demand on equipment in recent years has revised the general concept of maintenance and now we are concerned primarily with continuity of service, then length of necessary downtime, and finally cost of repairs. To meet these standards, the average maintenance department had to be reconstructed, the "Jack-of-all-trades" was replaced by specialists, and the department as a unit moved from a position of obscurity to one of rela-

Figure 1 — Steel plant service is hard on cranes which should be designed for this type of duty.



tive importance. The present day maintenance engineer fully realizes that the economical upkeep of equipment can only be achieved through a well directed preventive program. If a sound program is instituted and followed, repairs can be scheduled during normal working hours eliminating premium labor rates, production schedules can be revised in advance so that minimum loss occurs, and in most cases the chain reaction of one defective or worn part contributing to the failure of others can be prevented.

With all the importance attached to proper care of equipment there are still many units of production that are neglected. Of these the overhead traveling crane usually receives the least attention. Possibly this neglect is due to the normal somewhat inaccessible location of the unit. Actually when we consider the potential benefit of dependable crane service, there should really be more than normal maintenance applied.

In the average industrial plant, material handling will account for 30 per cent of production costs. With the crowded condition of most manufacturing facilities today, the only obvious efficient way of handling material is through the air with an overhead crane. It is only natural then that planned maintenance is essential to assure trouble-free operation and to reduce production costs.

What constitutes a good preventive maintenance program for overhead cranes? This is a question difficult to answer, and because of the vast difference in crane installations, what might apply for care and operation of equipment in a machine shop could be detrimental to equipment in a steel mill. By the same token what is necessary for a steel mill installation would be far in excess of upkeep required for an assembly floor crane. Since there are basic components which are common to all cranes, we can offer general recommendations for a preventive maintenance program. Let us consider some of these.

The overhead crane as a mobile machine tool must have a satisfactory foundation if expected to function properly. Therefore, maintenance must start with permanent features which are:

1. Runway.
2. Power supply.

The runway should be capable of rigidly supporting the combined weight of crane and load. If deflection of runway beams occur under load, excessive wear of bridge truck wheels will result. Thermal conditions must be considered and provisions for expansion at rail splices should be properly established. Should there be too great an opening at splices, flat spots will develop on crane truck wheels; too small an opening will cause rail alinement to become irregular when high ambient temperatures are experienced, and as a result excessive truck wheel flange wear can occur.

The danger of the latter condition is that when wheel flanges begin to scrub the rail head, the material disturbed is rolled onto the tread, which naturally will increase diameter of the wheel. More than likely only one of the driver wheels will be so affected, thus causing the crane to run out of square, with the result that abnormal maintenance problems will develop on the crane itself.

Considerable preference has developed of late for the floating continuous welded runway rail. Special clips to arrest float, replace standard J bolt fastening. Longitudinal expansion and contraction is accommodated by leaving ends of rail free from runway bumpers.

The crane runway bumpers should of course be adequate to stop the crane running at least 50 per cent of maximum speed without the shock damaging the runway or building. Finally they should be accurately mounted so as to provide a reference point for checking alinement of the crane bridge.

Runway rail alinement and span should be carefully checked at least once a year so that corrections can be made for normal settling of buildings or runway structures that occur through changes of seasons.

There are definite procedures which should be followed in alining runway rails. The rail adjacent to the power conductors should be set first. A check of dimension between center of collectors contacting runway conductors and center of adjacent truck wheels should be made so that when alinement is completed collectors will track properly. Lineup of this first rail on long runways should be made with a transit; on very short runways a chalk line can be substituted. The second rail is set using a steel tape. The span of crane as established in manufacture must be known. Using special tools available for adapting a spring scale to a steel tape, measurements in increments of not more than ten feet of runway length are taken. Pull on tape should be at least fifteen pounds for spans up to 70 feet and twenty pounds up to 100 feet. Bear in mind that excessive pull will stretch the tape and inaccurate measurements will be obtained.

Runway rail alinement should be maintained within a tolerance of $\frac{1}{4}$ in., if possible; $\frac{1}{8}$ in. is more desirable. We recognize that modern construction allows greater thermal effect on structures than heretofore, and also now that long runways are so prevalent, $\frac{1}{8}$-in. tolerance on rail spans would be almost impossible to hold, however, every reasonable effort should be made to maintain accurate alinement. After rails have been alined, power conductors can be checked by using an indicator rigged on the crane bridge. Irregularities should not exceed the float of collectors. Individual support brackets must be shimmed or reduced in size as required, to assure satisfactory pickup under all operating conditions.

Since most main line collectors are spring loaded devices, a periodic check of contact pressure is necessary. Shoe collectors should have from twelve to sixteen pounds pressure on the conductor. Double shoe collectors should have from six to eight pounds each.

Mentioned previously were two details of permanent nature that must be given first consideration in a maintenance discussion. The first detail was runway. The second detail was power supply. If there is any one item that the manufacturer of overhead cranes has encountered as a major problem, it is the crane power supply. To substantiate this statement, some case histories will be given. We sold two cranes to a scrap dealer out East. Shortly after the units were put into service, a motor failure occurred, followed by another and another, until a total of five were involved. After each failure a careful investigation was made, no concrete responsibility could be established. We checked and altered the control, and checked again, all to no avail. Finally out of desperation we assigned a field engineer to stay right on the

job and determine if some unusual condition was arising that could not be revealed by summary checks. He found that operating voltage of crane was 440 volts; length of runway was 400 feet. The position of runway tap was adjacent to crane access ladder at one end of runway (where all checking was done incidentally); recorded voltage of crane in area at opposite end of runway, where 90 per cent operation occurred with normal load was 278 volts. Adequate taps were provided in the runway, and the problem is now gone.

Not too many months after this unfortunate situation, a telephone call was received from one of our customers advising that he had generator trouble. After discussing the problem, it was determined that the small power plant facilities were used only for power to several d-c cranes. A new crane had recently been installed. However, all the others were a year or more older. One of the older cranes appeared to be causing all the difficulty. Under certain conditions the supply generator would flash over. A resume of total horsepower load indicated negligible overload on the generator. To aggravate the situation, however, when the crane suspected to be responsible for the difficulty was handling a capacity load at a point in the runway farthest from taps, with other cranes working, the line loss resulted in a voltage drop from 250 to 178 volts d-c, under the conditions. The hoist motor would stall and effectively short circuit the generator. Additional runway taps alleviated further complications.

In both of the cases related above, plant facilities were increased, consequently, the power demand factor increased, and subsequently the power supply was overloaded creating unsatisfactory voltage regulation. This same situation has been repeated many many times. Therefore, with the continuing expansion of most manufacturing plants, we recommend that the overhead crane power supply be reviewed periodically to guard against the possibility of overloaded facilities creating unsatisfactory voltage regulation. These experiences emphasize that the crane power supply cannot indefinitely be taken for granted. When periodic checks are made, of the voltage regulation, capacity loads should be handled in the areas farthest from the runway feeder taps. Where d-c power is used, satisfactory crane performance can be obtained with voltage fluctuating 10 per cent above or below rated voltage. On a-c cranes, although the motors and control can be safely operated within the same tolerances of rated voltage, we cannot neglect the fact that due to the inherent characteristics of induction motors, the torque and heating of the motor will vary as with the square of the change in voltage, and consequently, regulation that permits a 10 per cent drop in voltage, will not produce satisfactory crane performance. We recommend that regulation, for the most satisfactory results, be maintained within 5 per cent below rated voltage and 10 per cent above.

If for some reason or the other, there are no preventive maintenance efforts planned for any one specific overhead crane, there must at least be periodic lubrication of all moving parts. Because of the service factors encountered in the various installations of overhead cranes, frequency and quantity of lubricants must be determined through actual experience. Lubrication experts are as near as the telephone, to assist in reviewing requirements, and making specific recommendations for each special application. A crane manufacturer also presents a set of standard recommendations to serve as a basic guide.

There are now available one shot systems for adaptation to cranes where the duty cycle is so consistent that sufficient idle time is not available for necessary lubrication. This type of system should not be recommended for all cranes since the summary check which will result from a lubricator dwelling momentarily at each moving part of the crane, is eliminated. Also, the one shot system frequently over-lubricates some of the moving parts, with the end result that oil seals can be damaged, and large amounts of grease collect adjacent to bearings and bushings.

On the establishment of lubrication procedures, bear in mind that excessive lubrication can be as detrimental as insufficient lubrication.

The crane itself, for the most part incorporates details common to the mechanical and electrical engineering fields. There are some individual details which require special attention, and it is here where the progressive crane manufacturer excels when these features are designed for crane service and not adapted. The crane has, so to speak, an electrical heart. All motions, that is, hoist, bridge, and trolley, are controlled and regulated through electrical devices. In a review of the standards now applied to overhead crane control, it is quite evident that every conceivable effort has been taken to make them foolproof. Unfortunately, however, they cannot be made manproof, consequently, some difficulties still arise. Preventive maintenance on the crane in general, in reality means close periodic inspections of all the details, conducted by personnel fully conversant with the various devices used. It is usually necessary that electrical components be more frequently inspected than the mechanical details, since a multitude of circuit interruptions that occur in even one shift of operation, is detrimental to contact tips, etc., and consequently, more applied maintenance is necessary for trouble-free crane operation.

For purposes of discussion, let us consider the requirements on an overhead crane in a moderate duty cycle operating two eight-hour shifts per day.

A visual inspection of mechanical and electrical components should be made weekly. A more thorough inspection should be made on a monthly basis with a review of adjustment of brakes, functioning of the limit switches, condition of the bearings, gear trains and oil seals. Adjustment of collector shoes should be reviewed, hinge pins of the collectors should be lubricated, contact tips and segments should be inspected, and any phase of the circuit which might indicate the potential of high resistance, should receive proper attention. These monthly inspections will point up the development of any serious problem, and will permit sufficient warning to effect repairs prior to the development of a serious shutdown.

At least twice yearly a thorough inspection of the crane should be made. The following should be given special attention:

Mechanical — 1. Remove several of the fitted bolts to determine whether or not any shearing action has occurred at the corner connections.

2. Irregularity of wheel diameters, or misalinement

of the bridge will be evidenced by scrubbing of the wheel flanges.

3. Remove or loosen some of the drive shaft couplings to determine whether or not correct alinement of motors, gear cases and cross shafting still exists.

4. Check condition of all bearings and oil seals.

5. Carefully inspect hoisting cables. For obvious reasons of safety, replace if not in absolute first class condition.

6. Has the crane been lubricated satisfactorily?

Electrical — 1. Check line voltage at the motor terminals on all motions. It is obvious that this is a positive method of determining whether or not satisfactory conditions of all circuit components exist.

2. Review alinement and condition of collector shoes. Check the contact pressure, do not attempt to continue operation of the crane with worn or dilapidated collectors. One can well appreciate the hazard of operation under this condition to both equipment and personnel.

3. Check all movable and stationary contact tips both in the power circuit and control circuit. Replace or clean as required.

4. Determine if motor commutator or slip ring brushes are free to move in their holders. Also, from past experience determine that sufficient stock of carbon remains for at least another six months service.

5. Stone commutators and sand slip rings as required.

6. Review all wiring used, replace or repair any obvious damaged insulation.

7. Use a megger to check entire crane for high resistance ground faults.

8. Check motor winding bands for tightness. By placing one's finger on the band, and tapping in adjacent areas lightly, it can readily be determined whether or not motor bands are sufficiently snug.

9. At least once each year, remove all rotating electrical equipment and clean thoroughly. Windings should be cleaned with an acceptable solvent and blown off with compressed air. Redip and bake motor windings. Flush out old grease from the shaft bearings, examine carefully and replace if required.

10. Check all terminal points in the electrical circuit to eliminate the possibility of high resistant contacts.

Records of inspections and maintenance activities on all cranes should be maintained so as to provide a guide to assure whether or not the attention given the product was satisfactory.

We have discussed at some length recommended maintenance procedures. All reference to cost involved, has so far been carefully avoided. However, it is well before we conclude, to consider this angle. The establishment of a hard and fast rule for determining the cost of properly maintaining overhead cranes is an impossibility, for two reasons: first, "proper maintenance" is a general term with many definitions; and second, the degree of maintenance required will vary in direct proportion to the severity of service to which a crane is subjected. However, an example may shed some light on the subject. We have been informed that on overhead cranes operating under severe conditions such as in scrap yards, bulk plants, steel mills and so forth, maintenance costs after the first year of service will total about 5 per cent of the current replacement cost of the crane, for a single shift of operation. When second and third shift operation is involved, a diversion factor in the cost can be applied, and generally the cost will increase to about 7 per cent for two shifts per day operation and 9 per cent for three shifts of operation. This cost may on the surface appear somewhat excessive. However, we cannot neglect the fact that the crane is in a rather inaccessible location. Therefore, labor applied is at an extremely low efficiency.

Preventive Maintenance Insures Production

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. . . . included in preventive maintenance are such items as improvement of power factor, checking of insulation resistance, measuring hot spot temperatures and elimination of vibration . . . .

▲ THE old axiom "An ounce of prevention is worth a pound of cure" has always been applicable to maintenance practices in industry and today it is just as important, particularly for preventive maintenance. Preventive maintenance is actually based on the theory that "It is better to keep out of trouble than to get out of trouble." Preventive maintenance therefore means planned programs and schedules that will reduce to an absolute minimum the possibility of equipment breakdowns and losses of production.

The management of any operation in industry coordinates the functions of all of the respective departments into a successful and efficient operating organization which is capable of producing a quality product at the lowest possible cost. Consequently, the maintenance department in any organization becomes the real

key to the continuity of plant operations. It means, however, that a close cooperation must exist between management and maintenance staffs, and must be maintained in order to accomplish efficient plant operation.

Let us therefore realize that preventive maintenance is an important medium for preventing failure and outage of equipment by using a planned, organized program of periodic inspections of electrical apparatus. Such programs should include the maintaining of adequate records that are informative on the equipment, and the results of periodic inspections. In addition, these records represent excellent case histories of the equipment as to performance over a period of years.

Because of the many various classes of industries, and also the size of plants in those industries, there is no one general pattern of preventive maintenance program that can be utilized to meet all possible requirements. It therefore becomes necessary to make an analysis of all of the electrical equipment applications, taking into consideration also the duty cycle involved, in order to first provide a proper basis for the scheduling of inspections and corrective action. As an assist, there are various sources of reference literature applying to specific maintenance of various classes of electrical equipment. For example, there are many good trade publications that deal with maintenance problems. Also available are instruction pamphlets furnished by the electrical equipment manufacturers. These pamphlets are most important concerning the proper use and care of equipment, particularly special types of equipment. Preventive maintenance is therefore highly important regardless of the class of industry involved. Out of necessity, it must be wide in scope with numerous planned objectives. Each objective must be equally important and receive equal consideration for a successful preventive maintenance program.

Although there are numerous causes of equipment failures, an analysis over a period of years reveals that most troubles on rotating equipment are caused by dirt, moisture, friction, vibration, improper voltage, improper lubrication, chemical or acid fumes, overloads, and in some cases improper application. Maintenance inspection schedules must therefore incorporate precautions against such causes of trouble and also eliminate any threatened risks of equipment outage from wear, abuse, or abnormal operating conditions.

Preventive maintenance programming should include the transmission and distribution of power which involves wiring and cables, connections to controls, proper protective fusing and setting of relays, and particularly the oil so often neglected in transformer banks and in circuit breakers.

With reference to the general maintenance of controls, it is well to remember that many devices are involved, some of which require periodic attention such as overload, overspeed, reverse current, and circuit breaker trips.

Particular attention is required for the proper adjustment and setting of relays, and whenever possible actual tests of such devices should be accomplished in order to prove their protective value. Periodic checks of indicating instruments may reveal a false value of load conditions due to faulty calibration. Such indicating meters should be in proper condition, including calibration, in order to provide a true indication of load conditions for which such instruments were intended.

Cleanliness is without a doubt one of the most important factors for providing successful operation of electrical equipment, particularly so with rotating equipment. Many cases of motor and generator failures can be attributed to overheating due to insufficient ventilation caused by clogged air ducts in the windings. Clean windings can be maintained if such a procedure is incorporated in maintenance programs. Specific problems that involve proper cleaning of windings under severe operating conditions can be referred to the equipment manufacturers for their recommendations.

Although our discussion up to the present time has been confined to equipment in operation, let us not forget in the maintenance program to give some attention to the spare equipment stored in the plant for emergency replacements. Of course, a clean and dry location free from frequent atmospheric changes, is highly desirable. Such spare equipment represents not only an investment, but also good insurance when an outage occurs, and therefore should certainly be properly protected.

Another most important item in maintenance programming is adequate stocks of certain renewal parts. This means such parts will be available for immediate use from the plant stockroom. What parts to order, and in what quantities, can usually be determined from maintenance activity records. If no such case histories exist, requests to the electrical equipment manufacturers should be made for recommendations. A reference library consisting of renewal part catalogs for the various equipment installed is a necessity to expedite proper ordering and shipment of parts properly identified.

In the formation of preventive maintenance programs, one of the usual objectives concerns the reasons for power losses; for example, low power factor that can be improved by changing motors to fit a particular load application, or the installation of synchronous equipment. Also by the use of capacitors, power losses can be minimized. The benefits derived from the correction of low power factor are realized by relieving the burden of the useless current flow in transformer banks and other major equipment. Then too, there are other losses such as a motor operating at reduced horsepower that results in low efficiency and power factor. Oftentimes power circuits are also taxed far beyond the capacity of the original planning with the voltage conditions too low for proper operation of equipment.

In respect to rotating equipment, there are certain materials such as iron, steel, and copper used in the manufacture of motors and generators that inherently have long life. There are also additional materials used such as insulations of various classifications that have certain operating life properties dependent to a great extent on operating temperatures.

From an insulation viewpoint, particularly on the more important applications of motors and generators, it is advisable through preventive maintenance programming to arrange for a schedule of periodic insulation resistance measurements. Such procedure will definitely establish the trend of the insulation values over

a period of time. If and when a trend curve shows a continued lowering of insulation resistance, or a sudden drop in value takes place, then action for an investigation of the cause and corrective measures are in order without delay.

The question naturally arises as to what constitutes a safe-operating insulation resistance value, taking into consideration various factors such as the class of insulation, the operating temperature, atmospheric conditions, and the duty cycle. To determine a final answer, there are a few conditions that must be investigated in order to properly evaluate whether or not motors or generators are operating at too high a temperature. For example:

1. What is the internal temperature of the windings?
2. What is the ambient temperature in which the equipment is operating?
3. How is the temperature being measured?
4. What is the type of enclosure, if any is used?
5. What class of insulation is in the windings?

Let us first consider that the temperature of the internal windings at the "hottest spot" is where the insulation will receive the roughest treatment from heat — and that is where it will be destroyed first. However, as a practical matter, no one can get at that particular spot, so other facts concerning temperature will have to be utilized in order to determine how hot internal windings really are.

The temperature of the windings can be compared with the maximum allowable temperature for a particular winding utilizing Class A, B, or H insulations. For example:

Maximum Internal Temperatures

Class A insulation,	105 C
Class B insulation,	130 C
(Modified) Class H insulation,	160 C
(Full) Class H insulation,	180 C

If rotating equipment is operated at lower temperatures than stated, longer operating life can naturally be expected from the windings. On the other hand, if such temperatures are exceeded consistently, an appreciably shorter insulation life will result.

To express insulation life in another manner, it has been determined from study and analysis of various applications and failures that for every 10 degree C rise above the temperature values stated, the insulation life of equipment windings is cut approximately in half.

At this point, perhaps it would be advantageous to discuss briefly the definition of the various classes of insulation referred to — namely, Class A, B, and Full Class H, as standardized by the National Electrical Manufacturers Association.

CLASS A

Class A insulation consists of — (1) cotton, silk, paper, and similar organic materials when either impregnated or immersed in a liquid dielectric; (2) molder and laminated materials with cellulose filler, phenolic resins, and other resins of similar properties; (3) films and sheets of cellulose acetate and other cellulose derivatives of similar properties; and (4) varnishes or enamels as applied to conductors.

CLASS B

Class B insulation consists of mica, asbestos, fiberglass, and similar inorganic materials in built-up form with organic binding substances. A small proportion of Class A materials may be used for structural purposes only.

CLASS H

Class H insulation consists of (1) mica, asbestos, fiberglass, and similar inorganic materials in built-up form with binding substances composed of silicone compounds or materials with equivalent properties; (2) silicone compounds in rubbery or resinous forms, or materials with equivalent properties. A minute proportion of Class A materials may be used only where essential for structural purposes.

So much for the classes of insulation, and at this time it would be appropriate to continue discussion on internal temperatures of windings. Actually the internal temperature of windings is the sum of three factors. They are:

1. The "ambient temperature" which is the temperature of the air immediately surrounding the equipment.
2. The "temperature rise" which is the number of degrees that the hottest part of the winding, accessible for thermometer measurement, rises above the ambient temperature. This is the temperature rating that is usually indicated on the nameplate attached to the equipment.
3. "Hot-spot allowance" which is the difference that can be expected between the hottest inaccessible part of the windings and the hottest accessible spot. (As previously stated, the inaccessible spot of the windings will be the hottest).

Having obtained the temperature of the accessible windings, it is only necessary to subtract the ambient temperature from the winding temperature to obtain the temperature rise.

For the next step, the hot-spot temperature allowance should be added to the ambient temperature and the temperature rise. The proper hot-spot temperature allowance has been carefully determined by the manufacturer.

Hot-Spot Allowance (Motors and Generators)

Class A Windings	
Open, drip-proof and splash-proof	15 C
Totally enclosed	10 C
Class B Windings	
Open, drip-proof and splash-proof	20 C
Totally enclosed	15 C
Class H Windings	
Open, drip-proof and splash-proof	30 C
Totally enclosed	25 C

It is usual practice to make an analysis between the ambient temperature and the temperature rise. The manufacturer's nameplate on the equipment indicates a rating of temperature rise that has been based on an ambient temperature of 40 C. For example, if the ambient temperature is above 40 C (104 F) and the temperature rise is as high as the temperature value indicated on the nameplate, trouble can be expected unless the condition is corrected.

On the other hand, if the ambient temperature is below 40 C, it may appear that a motor or generator can be operated at a higher load which would give a higher temperature rise than the nameplate reading. However, be cautious because ambient temperatures have a bad habit of not being consistent as they will vary with atmospheric and load conditions.

Because of the necessity in some plants to use enclosures for greater protection to motor or generator windings, it frequently becomes inconvenient to use thermometers on windings of even the open type of equipment. It may therefore be necessary to use an alternate method of measuring temperature rise — namely by resistance. This procedure is simply a means of calculating the temperature rise in the windings by comparing its resistance before and at the end of a suitably long period of operation at rated load.

The relationship between ambient temperature, temperature rise, hot-spot allowance, and internal operating temperature is quite similar to those values obtained by thermometer. However, since the rise by resistance is a measure of the average temperature of the entire winding, it provides a temperature rise more closely approximating the hot-spot temperature than does the thermometer measurement. Consequently, the "allowable" temperature rise by resistance is slightly higher and the hot-spot allowance correspondingly lower.

Preventive maintenance programs and schedules can incorporate the investigation of operating temperatures of equipment as recommended. Such procedures will often reveal serious operating conditions through preventive maintenance that can be corrected before a sudden breakdown or complete outage occurs.

To give the best possible support to all industries using rotating equipment, intense engineering research is being conducted by electrical manufacturers at all times on both insulations and insulating varnishes. The main objective is to produce longer operating life of windings in equipment, taking into consideration all of the many types of applications and operating conditions experienced in various industries.

As rotating equipment has primarily been under discussion, inspection schedules of preventive maintenance should always be on the alert for one of the severe causes of trouble, namely vibration. With the definite trend towards higher operating speed in present-day electrical rotating equipment, proper and adequate balancing of rotating parts must be maintained. Unbalance in rotating equipment causes vibration that results in excessive wear and noise. The elimination of such vibration caused by either a mechanical or electrical unbalance can be accomplished through corrective measures which may be in the form of weight added to, or material removed from, the rotating part.

The unit of unbalance measurement in general is known as the "ounce-inch." An "ounce-inch" is the unbalance effect produced by a weight of one ounce at a distance of one inch from the axis in a rotating body. An unbalance of an "ounce-inch" creates a centrifugal force of 1.15 ounces at 200 rpm; but when the speed is increased to 5000 rpm, the unbalance of an "ounce-inch" produces a force of 44.3 pounds. Machine vibration may increase at a still greater rate than force increase due to the presence of critical speeds. With a speed increase of 25 times, the force produced by the unbalance of one "ounce-inch" increases more than 600 times.

Another most important objective in preventive maintenance programs involves the larger ratings of rotating equipment such as induction motors, and synchronous motors and generators. Such equipment should have periodic inspection through disassembly. There are numerous good preventive maintenance reasons for arranging for such inspection. For example, stator wedges may be loose allowing stator coil movement. Then too, the lacing of coil group connections and phase groups may be deteriorated causing movement and vibration.

Insulation under the steel retaining bands on armature windings may have shrunk resulting in loose bands and consequent movement and chafing of armature coils. Slot wedges in the armatures may also be loose, all of which contributes to vibration and dangerous situations for equipment failure.

Rotating fields of synchronous equipment should receive particularly close inspection. The renewal of top and bottom insulating washers on the coils may eliminate future possibilities of sudden breakdown and outage of equipment.

Preventive maintenance inspection of these larger ratings of equipment are usually scheduled over a period of time in order that all such equipment in the order of length of operating service and duty cycle can be adequately inspected. Depending on the findings of the inspection, corrective procedure can then be arranged to suit operating schedules. Maintenance records representing case history of such equipment should be maintained with proper detail of the inspection and any corrective work recommended or performed.

Maintenance personnel in any industry can usually enlist the help and cooperation of operators of various types of equipment in reducing overall maintenance costs. Such operators handling processes which involve both electric drives and associated control, often require suggestions and instructions relative to the proper handling of equipment. By so doing, neglect, and particularly abuse, can in most cases be practically eliminated.

Maintenance inspection schedules can and should be an important means of combating an increasing proportion of fires and resultant damage of an electrical origin. It is well-known that electricity in its various uses is a potential source of fire hazard and the many reasons are quite obvious.

Safety rules and regulations in the use of electrical power, regardless of the voltage, should always be respected and absolutely followed. Taking chances on improper handling and distribution of electrical energy results only in disaster.

The proper and adequate maintenance of electrical equipment is a dual responsibility of both industry management and maintenance staff organizations. The recognition which the maintenance organization receives from management depends very largely on performance, the ability to keep the equipment they are responsible for producing. In conclusion, "Preventive Maintenance Insures Production."

Shop Fabrication of welded steel water mains

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. . . . submerged arc welding enables fabrication of large diameter pipe and fittings . . . . ingenious application results in production economies . . . .

▲ MUCH has been published concerning design and construction of water main distribution lines; but here we are concerned chiefly with procedures of shop fabrication which is a necessary and time consuming part of these projects.

Works engineer — After a contract has been entered, all information, including designs, specifications, and contract terms are placed in the hands of the works engineer for prosecution. Under usual conditions, advance bills of material are written and orders placed with the rolling mills and other material vendors. On water main work it is first necessary to make an erection plan which shows all pertinent information such as profile of bends, location of field joints, and erection marks of pieces. Other information may be added, depending on the nature of the particular contract in question.

Preparation of shop detail drawings follows the erection diagram and is generally made in the same consecutive order as that in which the pipe sections are installed. The full listing of all material as well as welding grooves and processes and dimensions is included in the shop drawings. All pipe sections are thus drawn so that the shop may be clearly instructed on the sections to be fabricated. A general note sheet is prepared to include working information such as hydrostatic test, workmanship specifications, cleaning, lining and coating, and any other pertinent data. All the above sheets are given an independent check by a man whose past experience has been such that he is able to detect any corrections or additions necessary for the proper completion of the contract.

The erection diagrams, shop drawings and general note sheet are then sent for the customer's approval. Approval should be limited to the overall design characteristics and need not take the form of a check of all detail dimensions. Approval resubmission may be necessary if any significant changes are indicated by the customer.

Works engineer's office further prepares shop bills to indicate the application of material and the actual release of the work. Weights, where necessary, are calculated and entered on bills of finished parts. Water main contracts are generally let, however, on a basis of footage of pipe. In this case the shipper is advised about the actual billing length involved in each piece so that it may be properly manifested. Payment for specials may be on any one of several different contract bases and the proper billing must be indicated on the bill of finished parts.

Thus, the office of the works engineer is responsible for the translation of the contract to working drawings, the ordering of proper materials, the release of fabrication and shipment, and the proper billing to the customer of all materials furnished.

Preparation department — Fabrication of the water main begins upon release of shop drawings by the works engineer. Plate material is "run in" from the receiving yard and routed through the preparation operation. The first step is the double edge planer where the two long sides of the plate are machined to exact width. Machining is completed in one pass. Six cutting tools on each side remove as much as 1 in. excess width. The planer has a 32 ft stroke and will machine ¾ in. plate at a cutting speed of approximately 57 fpm. Next the plates are stacked in 3-in. thick piles and transferred to a heavy duty single planer where the ends are square planed. If the plates require beveled ends for field-welded joints, the ends are planed singly.

After the plate has been planed on all four sides, the long edges are crimped preliminary to the rolling operation. Edges are crimped for a distance of from 4 to 16 in. depending upon the diameter of the pipe. Crimped plates are then rolled on any one of three rolls, 21, 30 and 40 ft. The diameter, length and wall thickness govern the size roll used.

Plate material ordered by the works engineer conform to one of the ASTM specifications. Quality control of this plate material begins at the mill where a corps of metallurgical observers maintain constant control of chemical and mechanical properties of each heat or batch of steel. At the plate mill the heat number is metal stamped on each plate from the heat of steel. This heat number remains on the plate and serves as a means of permanent identification of the material. Mill test reports are issued by the mill to customer. They contain the heat number, ladle analysis, and mechanical properties of the steel.

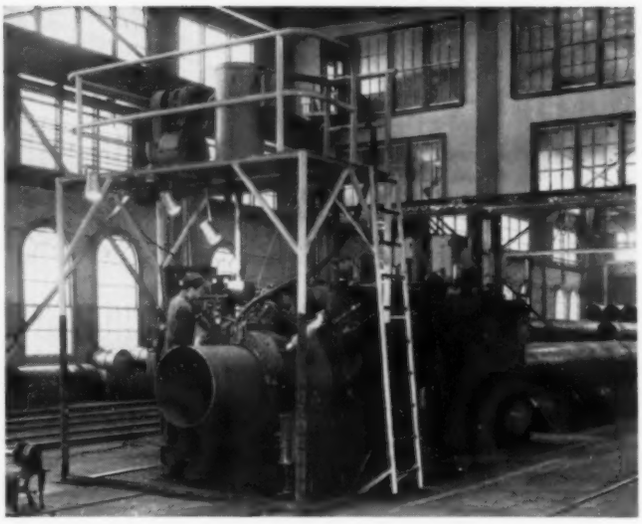


Figure 1 — Continuous automatic submerged arc welding of single longitudinal seam pipe is shown.

Before discussing the actual welding of the pipe, this paper will outline briefly the rudiments of the principal welding process — submerged arc welding. Following this discussion the method of welding and fitting and the weld quality required by a typical specification will be covered.

WELDING PROCESS

The welding of all straight pipe, whether of single or double seam construction, is accomplished by use of the submerged arc welding process. This process involves the following items:

1. Base metal.
2. A consumable steel wire electrode.
3. Source of electric current.
4. A granular welding flux.

After suitable edge preparation, the pieces to be joined are butted together and held in position by either tack welding or a welding fixture. Next an arc is established between the tip of the steel wire and the base metal. This arc is established and remains at all times under a blanket of granular welding flux.

A portion of this granular flux subsequently fuses and the fused portion provides a protective cover which prevents atmospheric gases from contaminating the liquid weld metal. It also dissolves any impurities that rise to the surface of the molten steel. In many respects its function is analogous to the slag in the open hearth steelmaking process.

The basic process is then mechanized by providing (1) a relative motion between the work piece and the welding electrode, and (2) an automatic wire feeding mechanism that balances wire feed and wire melt-off rate. The operation is then controlled at a central location by an operator who has finger-tip control of the welding current and voltage, the relative speed of the work piece and welding arc and the location of the welding arc relative to the joint.

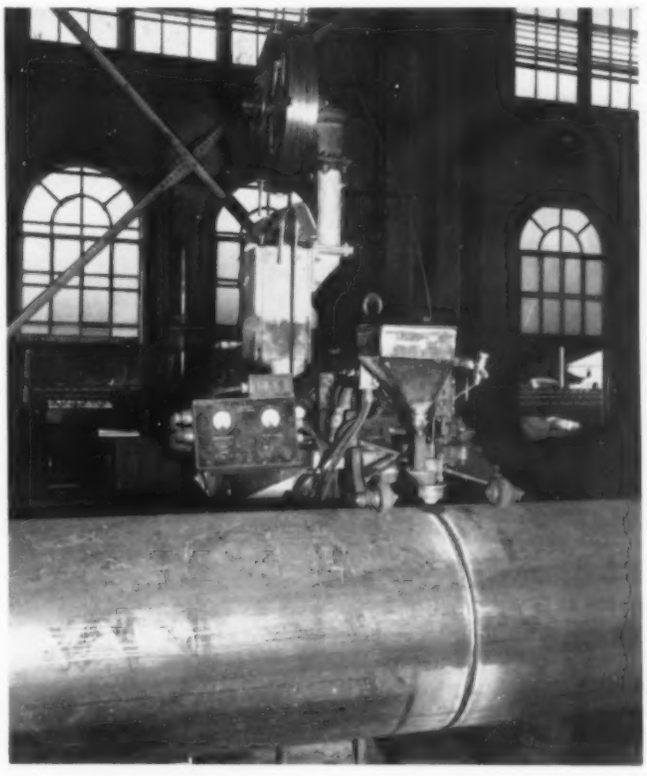
Thus the mechanization and automatic control of the submerged arc welding process have made possible high speed production welding and a resultant welded joint whose mechanical properties are equal to that of the base metal.

Method — The diameter and thickness of the pipe desired by the customer determines the construction and method of fitting and welding. Our standard length is 40 ft regardless of diameter. Diameters up to and including 36 in. outside diam are constructed of two 20 ft single longitudinal-seam pipe sections welded together at a girth seam. This is due to limits of diameter and length of roll equipment. Pipe above 36-in. outside diam are constructed of multiple longitudinal seams. The number of longitudinal seams is usually determined by the economical width of plate. Two seams or two plates per pipe usually go up to 76-in. diam pipe. Above that diameter three or more plates are used.

The single longitudinal seam pipe is welded on a continuous pipe welding machine (Figure 1). The seam is submerged arc welded near the discharge end of the machine. In the illustration can be seen an operator who controls welding speed, voltage, current, edge alinement of seam, and also guides the welding arc on the seam. As the circular joint approaches the discharge end of this machine, two welders tack weld the two sections together in preparation for the welding of the girth seam. When the outside pass of the longitudinal seam has been completed, the 40-ft length of pipe moves to a circular seam welder.

The joint preparation of the longitudinal and circular seam depends upon thickness of material. Normally we employ a square butt preparation for material up to and including ½ in. thickness. Above ½ in., a double vee groove preparation is used. Welding speed also varies with plate thickness. Currently we use single arc welding and attain speeds up to 45 in. per min on ¼-in. plate and progressively lower speeds on thicker material. To get maximum weld penetration a copper water cooled back-up shoe is used. The shoe is spring loaded and constantly presses against the under side of

Figure 2 — Welding apparatus shown is used on girth seams.



the welded joint. Unfused flux is recovered and re-used. The fused material is discarded.

After the outside pass of the longitudinal seam is completed and the girth seam tack welded, the pipe moves to a circular welding apparatus (Figure 2). The inside weld pass is completed first. Welding speeds again depend upon thickness of material. Note a central control station where welding variables such as current, voltage and speed are controlled by one of the two welders.

Upon completion of the welding of the girth seam the pipe moves to a third welding position. Here the inside longitudinal weld seam is completed. The method is to enter the pipe over a cantilevered boom on the end of which is mounted an automatic welding head.

After all welding has been completed, the pipe moves through the shop to inspection, round-up, and hydrostatic test.

Two seam pipe — As mentioned previously, pipe above 36 in. outside diam is of a standard 40 ft length and constructed with two or more longitudinal seams. After the plates have been rolled to the required diameter, they are fitted and tack welded together.

Following the fitting and tacking operation, the longitudinal seams are welded (Figure 3). The equipment consists of an outside welder and a cantilevered boom type inside welder.

With the longitudinal joints in the twelve and six o'clock positions, the outside top and inside bottom welds are made simultaneously. Upon completion of these welds the pipe is then rotated and the procedure repeated. As before, all continuous welding is of the automatic submerged arc type. Upon completion of these welds the pipe then moves to inspection, round-up, and hydrostatic test.

Considerable time is required in the fabrication of special sections (Figure 4) such as bends, elbows, reducers, tees, etc. When these are of sufficient length they are fabricated from straight 40-ft lengths by cutting to templet then assembling the parts and welding. The more complicated sections are developed from flat plate before rolling and welding. Most of the welding of specials is manual arc type using coated electrodes.

There is a "behind the scenes" activity that is not at once evident to the casual observer. This has to do with the means of maintaining a high level of weld quality and a guarantee that our customer is getting a quality product. This activity centers around workmanship specifications.

Figure 3 — In automatic welding of double longitudinal seam water pipe, outside top and inside bottom seams are welded simultaneously.

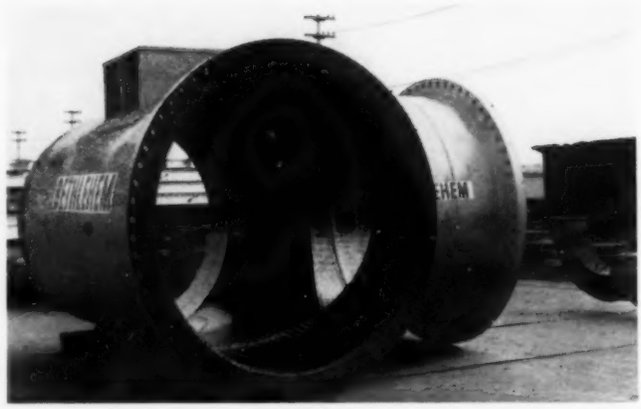


Figure 4 — Tee section of water main shown has opening of 83½-in. inside diameter and length of 10 ft 11 in. Inside is coated with bitumastic enamel.

SPECIFICATIONS

As a part of a contract the customer establishes the workmanship standards that shall be maintained during the fabrication of the pipe. These standards are sometimes covered by municipal specifications but more likely in accordance with standards set up by the American Water Works Association.

Since most of our work is fabricated in accordance with the latter specification, the production weld requirements outlined by the "AWWA Standard Specification for Electric Fusion Welded Steel Water Pipe of Sizes 30-in. and over" — C-201-50 will be discussed.

Arc welding equipment — This specification requires that welding generators and transformers shall be capable of delivering a constant current through a range ample for the requirements of the work and that they shall be equipped with meters showing welding current and voltage at all times. Suitable automatic welding heads, auxiliary handling equipment and welding cable are also subject to the requirements of this specification.

Welders — The welding personnel of the Steelton Works is divided into manual, semi-automatic, and automatic machine welders. As outlined by the AWWA our welders are tested periodically by an outside inspection agency in accordance with the standard qualification procedure of either the AWS or paragraph U-69 of the ASME Code for Unfired Pressure Vessels. Under these requirements our welders must demonstrate their ability to produce butt and fillet welds in all positions used during construction. The performance of a bend test of the weld is the measure of an operator's proficiency.

In accordance with the terms of the AWWA requirements, weld test specimens are made for every 300 lineal feet of pipe or every seventh 40 ft pipe. These weld specimens may be cut from the seam of the pipe or from test plates welded to the ends of pipe sections. In our shop we prefer to attach weld test plates to the pipe itself. The preparation of the edges of the test plates, the welding process, procedure and technique

and material specifications are the same as used in fabrication of the pipe.

From this test plate the following weld specimens are cut (Figure 5):

1. Two etch specimens.

One etched specimen is cut from each end of the test coupon, polished and etched in a boiling solution of equal parts of hydrochloric acid and water for a sufficient period of time to reveal any lack of soundness in the cross sectional area of the weld.

2. One reduced section tensile test.

The reduced section tensile test specimen must show a yield point and ultimate tensile strength not less than the minimum requirement of the plate material.

3. One free bend test specimen.

The elongation across the weld surface of the free bend test specimen shall be at least 20 per cent. Cracks on the convex surface of the weld greater than $\frac{1}{16}$ in. constitutes a test failure.

4. One reverse bend test specimen.

The reverse bend specimen shall be bent around a mandrel whose diameter is equal to the thickness of the specimen and through an angle of 30 degrees. The weld must be free of the evidence of lack of fusion and surface cracks.

5. One nick break test.

The fracture of the nick break test shall show complete penetration through the entire thickness of the weld, an absence of oxide or slag inclusions and a degree of porosity not to exceed six gas pockets per square inch whose maximum dimension is not to exceed $\frac{1}{16}$ in.

Other test requirements — There are exceptional instances such as unusually high pressures, large diameters, heavy plates, or other special conditions which may in the opinion of the purchaser justify the added expense of requiring the parts to be thermal stress relieved and radiographed. The AWWA accepts the standard requirements of stress relieving and radiography as outlined in the API-ASME Code Unfired Pressure Vessels for Petroleum Liquids and Gases.

The Steelton Works of Bethlehem Steel Co. is equipped to heat treat parts and is also equipped with a 218-kva rated x-ray unit capable of examining plate up to 2 in. in thickness. Beyond 2 in. plate, radioactive cobalt 60 is used to determine plate and weld metal soundness.

In addition to contract requirements, our radiographic facilities are used as a means of maintaining a high level of weld quality. For example, one complete pipe per turn from each automatic welding station is arbitrarily selected and radiographically examined. We believe this system gives us a constant daily check of the welding procedure, i.e. those factors that affect weld bead penetration; speed, current, voltage, equipment (ability to track on seam) and welder's proficiency as an operator.

Figure 5 — Weld test coupons cut from test plate of pipe are fabricated in accordance with American Water Works Association Workmanship Specifications.

Inspection, round-up and hydrostatic test — Following the welding operation, pipe is inspected visually. Weld defects such as pinholes, undercuts, cracks, etc., are chipped out as required and rewelded.

The outside circumference of each pipe at the ends is measured with a steel tape. Tolerances set forth in AWWA specifications allow $\frac{1}{8}$-in. oversize and $\frac{1}{16}$-in. under the inside circumference as computed from the specified nominal inside diameter.

Out of roundness of pipe ends is determined by a ring gage with an inside bore that is $\frac{3}{32}$-in. larger than the outside circumference of the ordered pipe. Pipe that does not meet this tolerance is routed to a roundup press where the ends are rounded to conform to AWWA requirements.

Hydrostatic test of pipe—All pipe sections and special sections are subjected to a hydrostatic test pressure equal to two times the working pressure of the line. According to AWWA specifications, bands fabricated from pipe previously tested are not subjected to a hydrostatic test. Bends not fabricated from tested pipe, and special connections are subjected to a hydrostatic pressure equal to $1\frac{1}{2}$ times the working pressure. Pipe is held at test pressure for a period of from two to five minutes during which time all welded seams are inspected for leaks. Leaks occur very infrequently but when found are repaired by chipping and rewelding.

Our hydrostatic test machine is designed for pipe from 20 to 80-in. outside diam and from 6 to 40-ft long. The maximum test pressure for this machine is 1230 psi. For larger diameter pipe, as an example 48-in. diam, the maximum test pressure would be 540 psi.

Coating — The purpose of coating a steel water main is to provide maximum protection from the destructive action of underground corrosive agents and crustaceous growth on the inside.

The bitumastic enamel is a specially formulated coal tar pitch which possesses special corrosion resisting properties. These include: (1) imperviousness to water, (2) electrical insulating properties, (3) chemical inertia, (4) stability at temperature extremes (minus 20 F to plus 160 F), (5) resistance to mechanical damage, (6) and a ductility that allows coating to adjust itself to operating stresses and strains without cracking and spalling.

However, to take full advantage of its protective properties the coating materials must be applied properly, and conform to the AWWA Standard Specifications for Coal Tar Enamel Protective Coatings for Steel Water Pipe. This specification outlines material, workmanship, inspection, testing, and handling standards. If carefully observed, the resultant coating is the best quality attainable.

The first step in the coating operation is to make sure that the pipe surface is free of rust, mill scale, welding slag, grease, oil and other foreign materials. Pipe at the Steelton Works is grit blasted to clean bright metal.

Any grease or oil that remains after the blasting operation is removed with primer solvent.

Following blasting, the pipe is then sprayed with a bitumastic primer whose function is to provide maximum adhesion between the pipe surface and protective coats. The primers are designed to adhere tenaciously to the steel and at the same time provide a compatible and adhesive base for the bitumastic enamels. The primer is then aged for a period of 24 to 48 hours. Aging time is dependent upon temperature and humidity. If enamel is applied to green primer, blistering and poor bonding will occur. A poor bond will also result if the primer is over aged.

Next the water main is coated with a bitumastic enamel. This enamel is charged into kettles where the material is melted and maintained at a temperature of 480 F. The temperature of the enamel is critical, as above 500 F volatile oils are driven off and the enamel coating becomes hard and brittle. If the temperature is too low the surface of the coating may become uneven and lumpy.

From the holding kettle, the enamel flows into a specially designed trough that is electrically heated. With a measured amount of enamel in the trough, the trough is placed inside the pipe and inverted with a uniform rotation while the pipe is spinning about its longitudinal axis. This process is generally called centrifugal casting. Surface speeds of 800 to 900 fpm are generally used. The amount of enamel charged into the trough is calculated to give a $\frac{3}{32}$-in. thick coating. To assure a uniform thickness of coating, the trough must be straight and level, and the pouring lip must be free of solidified enamel. If the trough is not level the enamel will be unevenly distributed over the length of the pipe. Solidified enamel on the pouring lip will divert the flow of enamel during pouring and create a band of uncoated steel around the circumference of the pipe. After the enamel has been poured, the trough is withdrawn and air is blown through the spinning pipe to set the enamel.

The outside coating is then applied. Enamel is pumped from an electrically heated kettle to a wide flat nozzle which covers an 18-in. width. While the pipe is rotating this trough moves at a uniform speed along the length of the pipe to complete the coating. A layer of asbestos felt, kraft paper, or glass fiber is applied with a second enamel coat of less thickness. The rotating speed of the pipe and lineal speed of the car are adjusted in accordance with the diameter of the water pipe being coated.

After coating the inside and outside, the pipe is inspected by means of an electrical holiday detector. A "holiday" is a term referring to a break or a pin hole in the pipe coating. These defects are detected by equipment designed to produce an arc across an electrode and the exposed pipe. The electrode used for the inspection of the outside coating consists of a spring coil wrapped around the pipe. The spring coil becomes the electrode and any void in the coating is detected as the coil is moved progressively along the length of the pipe. Under normal atmospheric conditions 1200 volts is adequate to produce a $\frac{1}{32}$ in. arc length. With a safety factor of 2, a 7200 detector voltage is recommended when testing coating of a nominal $\frac{3}{32}$ in. thickness. Defective areas are marked and repaired by a touch-up crew. The inside pipe coating is similarly inspected, but here a copper wire screen is used for an electrode.

The depth of the coating is inspected with a depth gage immediately after the spinning operation and also when the pipe is on the inspection skids.

After the pipe has been inspected and repaired as required, a coating of water resistant whitewash is applied to the outside and that portion of the inside that might be exposed to the direct rays of the sun during storage or shipment. The purpose of the whitewash coating is to provide a surface which reflects rather than absorbs the sun's rays. Temperature inside a pipe is reduced by 20 F by the addition of the reflective surface.

After pipe has been coated, special precautions are taken to prevent mechanical damage of the coating during handling. Either canvas or leather slings, or hooks which grip the pipe at the uncoated ends are used to carry pipe. Bare cables, chains, metal bars, narrow skids, etc. are not allowed to come in contact with the coating. When shipping by rail each pipe is supported on saddles padded with burlap. Pipe sections are also loaded in such a manner that they do not bear against each other. The whole load is fastened together and to the car to prevent sliding in transit.

DISCUSSION

PRESENTED BY

R. E. METIUS, Welding Engineer, Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

H. C. VON BLOHN, Welding Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Steelton, Pa.

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

C. W. DUNN, Supervisor, Equipment Installation, United States Steel Corp., Fairless Hills, Pa.

R. E. Metius: In one figure showing the coating on the inside of a section of pipe, the welding reinforcement on the inside of the longitudinal joint was visible even after coating. Since the coating is applied to the inside of the pipe by spinning, do you not end up with a thinner coating along the weld reinforcement? How is that overcome?

H. C. Von Blohn: The amount of weld reinforcement on the inside of a coated pipe is a critical factor. Poor coating coverage will occur during the spinning operation if the weld bead reinforcement is too high. The American Water Works Association specification allows a $\frac{1}{16}$ in. maximum reinforcement. We are able to stay within this limit by adjusting either welding variables, i.e. arc voltage and electrode diameter or weld joint design.

C. E. Pritchard: I noticed that prior to the pyramid roll operation you had a side crimping operation performed on the plate. Is there any sand-blasting or similar type of surface preparation provided in this weld area? After the pipe is formed and you have completed the outer weld and inside weld, what method is used to assure the concentricity of the pipe section as

formed? Mention was made of a subsequent operation as being processed on a round mill, but I am not clear in this regard. Usage of a ring gage was indicated. What happens if the ring gage indicates the pipe is out of round? What method do you have for getting the section back to round?

H. C. Von Blohn: Plate preparation does not include shot blasting the surface of the steel adjacent to the weld joint. We do use a preheat torch to remove loose mill scale, grease, etc., on our continuous pipe welders.

After a pipe moves through the weld clean-up area, its roundness is checked by a ring gage. If the pipe does not pass this test, it is then routed to a so-called round up press where the out of roundness is corrected by pressing the pipe between two dies located diametrical opposite each other. Pipe is then rechecked with the ring gage.

C. W. Dunn: I would like to know whether the qualification tests by the outside outfit are made at random or whether they are only specific test specimens?

H. C. Von Blohn: I will assume that your question has to do with the qualification tests given to welding operators. These tests are not given at random in that we have established a routine whereby each welder is requalified by an outside inspection agency every two years. The weld tests that are given conform to operator qualification requirements as outlined by AWS and ASME codes.

By R. BOYER, Assistant Superintendent, Mechanical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

Selection of Spares for a Steel Plant

. . . . selection of spares is difficult . . . . an adequate amount must be kept to insure continuity of production . . . . an overabundance of spares is uneconomical because of capital tied up in inventory, and expense of unnecessary storage . . . .

▲ PROPER selection of spare parts is of prime importance to any industry where continuity of operation is paramount and where down-time must be held to a minimum. The problem becomes one not only of selecting enough spares, but also one of economics. The purpose of this report is to point out some of the problems that arise when the initial spares are being purchased to maintain new steel plant equipment.

The steel industry has expanded considerably since World War II. The increase in capacity of 35,000,000 tons has cost nearly $6,000,000,000 for plants and equipment alone. The steel industry is probably the most mechanized of all industries. Considerable study must be given to the purchases of spares so that the new facilities will be adequately covered. It is uneconomical to have too few spares, and equally so to have too many. Most maintenance work revolves around three things; first, the foreman; second, the maintenance force; and third, the spare parts on hand. None of the three can be neglected and yet an overabundance of any is nearly as bad as a scarcity. Experienced foremen and engineers who have the knowledge gained from existing plant equipment are invaluable to any future expansion program. These people have many aids at their command in selecting new equipment spares.

First, before anything constructive can be accomplished, there must be final drawings or at least preliminary layouts of the new mill, furnace, or unit under consideration. Usually the engineering department supervises and coordinates an expansion program. These drawings are the product of many hours of discussion and planning by management and their engineering, operating and service departments. If the design is a new one and the equipment to be purchased from an outside supplier, their engineers or designers must be called in to help clarify the details. If the maintenance foreman is to select the spares, he will examine the drawings carefully in the hope that the new design will embody a standardization of machine components. His primary thought is to reduce the need for buying duplicate spares. That is, duplicates of machinery components he already is maintaining. He will recommend for change any detail that, according to his experience, will result in poor service life or difficult assembly. The task of getting the outside suppliers to change from their standard design is a difficult one because it usually extends the completion of final drawings and may raise the initial cost, but is well worth the effort. In the final analysis, it is easier and cheaper to change a drawing design than suffer breakdowns and emergency alterations. The need for presenting drawings and other important data to plant operating and service personnel at the earliest possible date cannot be overstressed if the new facilities are to operate with minimum downtime from the start. The result of the preliminary study by the maintenance foreman will be a tentative listing of the maximum number of unlike parts that are subject to failure by wear, fatigue, shock and accidental breakage.

The next step is to justify this spares list by analyzing each machine component in several ways.

The expected service of life of each bearing, shaft,

belt, motor, gear and the like should be estimated. The use of service records kept by maintenance departments servicing the same type of equipment will reduce errors in judgment. For instance, the records would indicate that failure by normal wear is the general rule in a bar mill, while in a blooming mill, failure by shock and fatigue reduce expected service life of machine parts. A six months' supply of consumer items such as guides, shear knives, bronze bushings, rolls, gears and the like should be on hand for the initial start. A change in plant shops' delivery lead time and outside suppliers' delivery lead times will change this six months rule, however.

The use of the same spares or common spares by more than one department, mill, or furnace, is convenient under a centralized form of maintenance, because it permits centralization of supervision as well as of storage facilities. A cooperative program of common spares between different steel plants might be developed, especially where expensive items are involved, such as mill drive motor armatures, blast furnace bells, hot strip mill drive gearing, turboblower rotors and large transformers.

Still another aid in the proper selection of spares is the knowledge of "minimum time." Now, a spare should not be considered as such unless it is assembled to the point where the least time is required to install it when trouble is encountered. The determining factors are questions of invested capital, how much is lost by stopping operations, and if lost time can be recovered. For example, a bare shaft might be ample spare for a drive on an individual shearing line, while a completely assembled reduction unit might be the minimum economical spare for a continuous hot strip mill where down-time costs are extremely high.

Some spares selected might not be needed for years, but their purchase is justifiable as insurance against an unforeseen failure or wreck. For example, spare mill-drive pinion gears must be kept on hand for primary mills, although their service life is considered in years, but a fatigue failure might result in the first few months of mill operation. The purchasing lead time of such pinions is rarely less than six months long.

The size and availability of shops within the steel plant must be considered in deciding the degree of assembly of spares. On a breakdown basis, plant shops can handle most assembly jobs of the steel plant in a few hours. Where forgings or castings are to be made, the minimum time becomes days. Rush repair jobs disrupt any shop control system and should be resorted to only for assembly of parts on breakdown basis.

The spares selection of new outside purchased parts should be tempered with a program of ordering new spares from the steel plant shops if their capacity is adequate. The selection of the best chemical analysis and heat treatment for the spare parts, taking into account whether the service is light, average, or severe is the joint job of the materials engineer and maintenance foreman. Good lubrication is the best aid to reducing the quantity of spare parts needed. Automatic lubricating systems are too often thought of as being expensive. The saving of spare parts and repair labor soon proves the contrary. They should be engineered, with piping installation drawings and some practical method of cleaning the scale and dirt from the piping before the lubricant is added.

Finally, when the spares list has been altered by minimum times, lead times, and shop times, the estimated cost of each item desired should be determined. Sometimes, this is done by referring the job to the outside equipment supplier, or the costs may be arrived at from previous purchases. The total cost of spares should be within reason when figured as a percentage of the original equipment cost. The operating and service departments should work together in justifying the real need for spare equipment when the spares total is too high. Some items might be deleted from the initial purchase if the operating people agree on a more lengthy emergency repair time.

When the average costs of initial spares is taken as a percentage of previous original equipment cost, less freight, erection, foundations, wiring, etc., they are aids in providing initial requests for appropriations for spare parts. This should be done at the same time provisions are made for the primary equipment.

Some of these percentages are as follows:

Coke ovens spare parts cost 4 per cent of the original equipment cost.

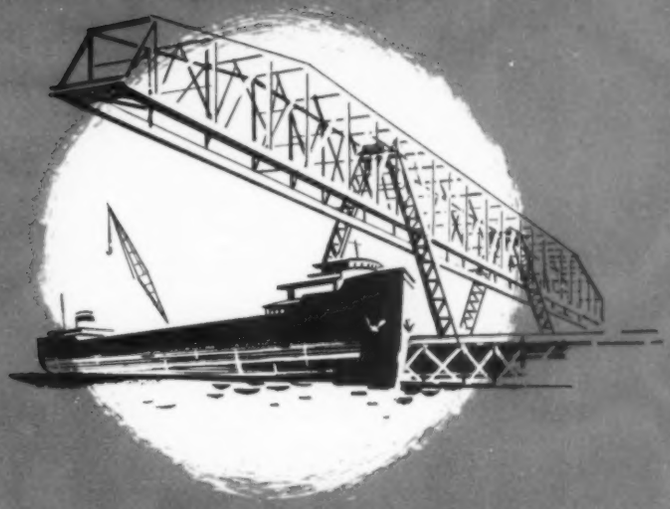
Blast furnaces and auxiliaries	6 per cent
Turboblowers	3 per cent
Open hearth furnaces	3 per cent
Open hearth charging machines and cranes	20 per cent
Soaking pits	4 per cent
Heavy mills and auxiliaries	15 per cent

This includes mechanical and electrical spares based on previous construction programs.

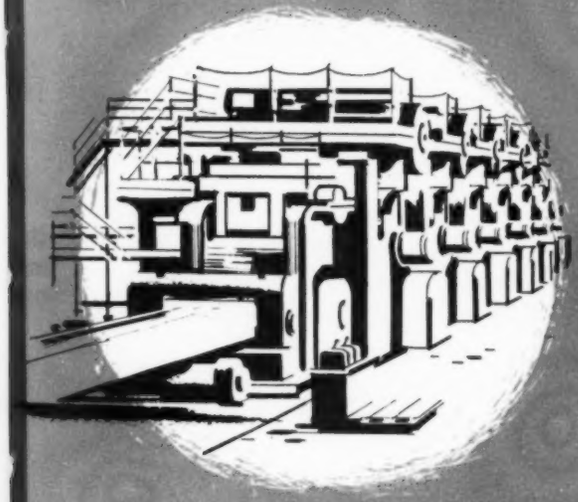
The cost of storing spares is no small item. Suitable facilities should be provided before delivery. The spares must be protected from the weather and damage by mishandling, and yet must be available for use within short notice. They must be inventoried on spare parts cards and tagged as soon as they are received. Any reasonable reduction in spares purchases is reflected in reduced storage costs.

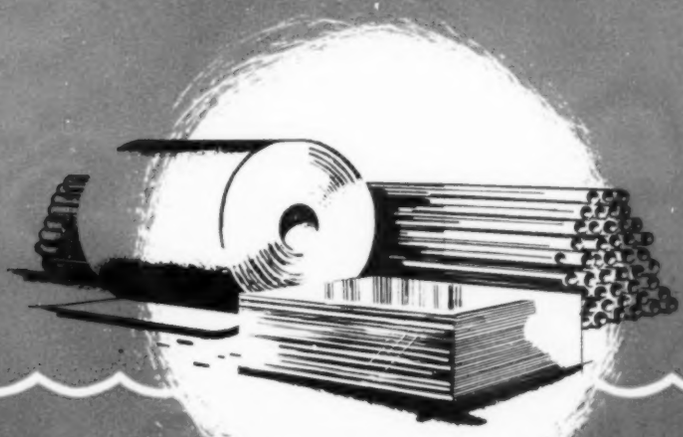
The degree to which any maintenance organization practices preventive maintenance and scheduled machine and electrical inspection, determines whether a maximum or minimum quantity of assembled spares must be kept on hand. So-called breakdown maintenance is never economical. Every good maintenance man strives to know, not guess, the condition of his equipment. Spares replacements on normal scheduled repair turns is the ideal he attempts to achieve. Planned inspection helps to reduce the quantity of expensive completely assembled unit spares. In fact, it is justifiable to have no spares at all for a given unit, if the continuity of operation is not important, loads are light and service life long.

In conclusion, the job of selecting spares is no easy one. Wherever possible, standardize, and search for common spares in different departments, even in different plants. Make someone experienced responsible for spares selection at the very start of a construction program. The top limit and bottom limit in dollars should be considered. Make some leeway for change in this limit if the real need for more spares is proven. Arrange to get spares with the new equipment. Set up a yearly buying program for expendable items and, last but not least, provide for spares storage. The end result will be reduced maintenance costs and increased production.



Youngstown in Chicago...





YOUNGSTOWN

Youngstown in Chicago...

Youngstown Sheet and Tube Company's Chicago District

By T. J. Ess

▲ THE Youngstown Sheet and Tube Co., ranking sixth among the steel producers of the United States was organized in 1900, and through a well-planned program of mergers and construction has attained a production capacity of 5,520,000 tons of ingots per year, with a well diversified line of products.

An important step in the development of this company to its present standing was its entry into the Chicago area in 1923 through the purchase of the plants of the Steel and Tube Co. of America. These plants, now known as the Chicago district of the parent company, have been expanded and modernized, and today present a completely integrated operation located near important markets and with easy access by rail and water to raw material supplies. Annual capacities are now set at 1,538,500 tons of coke, 1,976,600 tons of iron and 2,676,000 tons of open hearth steel ingots.

The main plant in this district is located on a site of more than 600 acres on the shore of Lake Michigan, about 20 miles below Chicago. It now includes three batteries of by-product coke ovens, three blast furnaces, 17 open hearth furnaces, two blooming mills, a billet and bar mill, two skelp mills, two merchant mills, two continuous pipe mills, an electric weld tube mill, a hot

The Harbor plant site affords excellent transportation facilities by water and rail. The new cold reduced sheet mill may be seen at the upper left, immediately beyond the hot strip mill and tin mill. The new open hearth and blooming mill are at the extreme right.

J. L. MAUTHE
President

A. S. GLOSSBRENNER
Vice President-Operations

strip mill, and cold mills and finishing facilities for the production of cold rolled sheet and tinplate. Another plant nearby provides additional capacity for coke and pig iron.

It has always been the company's policy to acquire raw material reserves, and it now owns or has part interest in some 20 mining companies operating iron ore mines on the Mesabi, Cuyuna and Vermillion ranges in Minnesota, and on the Gogebic, Marquette and Menominee ranges in Michigan.

The company also has an interest in the new Labrador ore field and in a taconite plant now under construction in Minnesota. It is expected that this plant, designed for a production of 7,500,000 tons per year of 63 per cent Fe taconite pellets, will start operation in 1957. The project includes a milling plant near large open pit mines, a townsite, a 73-mile railway from the plant to Lake Superior, and a harbor and power plant on the north shore of the lake.

Part ownership is also held in a shipping line operating vessels on the Great Lakes.

Substantial reserves of bituminous coking coal are also owned or operated under long leases in Pennsylvania and West Virginia. High-volatile coking coal for the Chicago plants comes from mines in West Virginia, principally the Dehue mine at Logan. Low-volatile coal comes mainly from company reserves in McDowell County, West Virginia. Most of the steam coal used in the plant comes from Indiana and Illinois.

Limestone for the Chicago district comes from a large quarry recently developed near Alpena, Mich. This quarry is operated under lease by a partially-owned corporation.

Coal, ore and limestone are, for the greater part, received by water shipment. The unloading dock lies along a canal extending inland from the lake, and is served by four unloaders, two of 8-ton capacity, two of 12-ton. Ore and stone are deposited in a trough running the length of the ore yard, which is 434 ft wide × 1675 ft long. These materials are then moved into the yard area by one 22½-ton bridge and two 15-ton bridges. These bridges also handle the material from the storage into 60-ton transfer cars operating on the blast furnace high line. No grading or sizing is done on the ore at this plant.

The ore yard provides storage for 1,300,000 tons of iron ore and 300,000 tons of limestone.

Coal received by water is unloaded into a large

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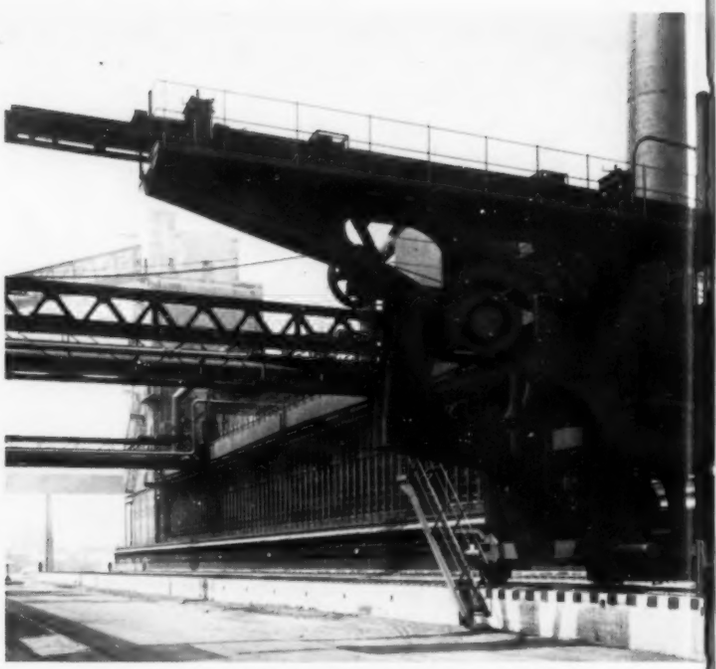
Gen. Supt.
Strip & Tinplate Dept.

O. B. HERBENER
Gen. Supt.
South Chicago

Lake front location permits carriers to dock adjacent to the ore yard. In the left foreground is a conveyor which carries coal to a storage yard.



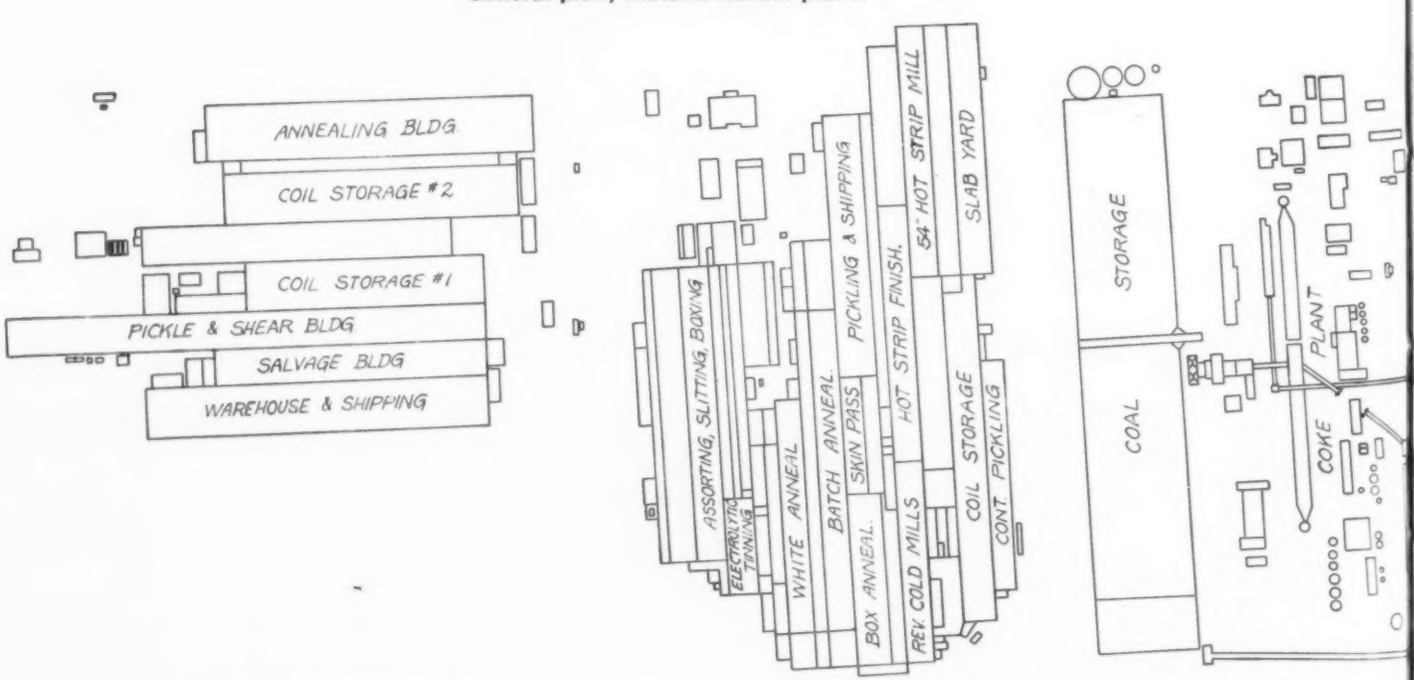
This battery of 75 underjet coke ovens cokes 1800 tons of coal per day. It normally operates on an 18-hour coking time, with each oven taking an 18-ton coal charge.

hopper, from which a belt conveyor system moves it some 1700 ft to the coal storage yard 280 ft wide × 1389 ft long, served by a 15-ton bridge capable of handling coal at a rate of 1000 tons per hr. This yard provides storage capacity for 390,000 tons of coal, which is not sufficient to carry the plant through the winter season. Consequently, rail shipments are necessary during several of the winter months. To handle such shipments, a 70-ton car dumper is installed at one side of the storage yard.

COKE PLANT

Coal for coking is handled from the storage yard bridge or from the car dumper by belt conveyors leading to the coal preparation building. Here it is crushed and put into four storage bins. A feeder belt from each bin brings the desired amount of the various coals together, and the mixture passes through two hammer mills, where it is crushed so that about 80 per cent passes through a ⅛-in. mesh screen. The crushed coal

General plan, Indiana Harbor plant.

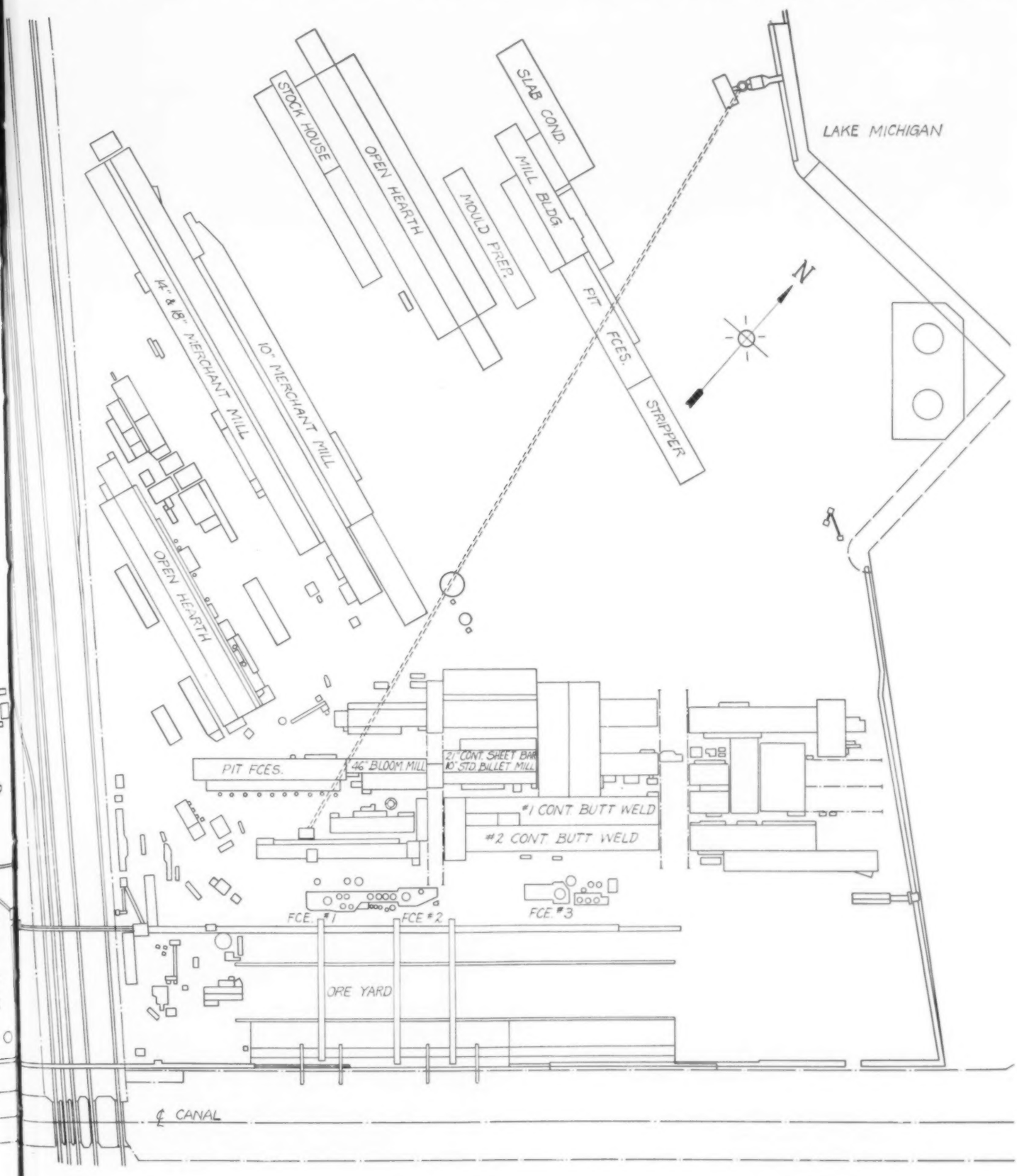


is then conveyed on belts to the coal storage bins at the oven batteries.

The usual coal mixture consists of 70 to 72.5 per cent high volatile coals from Eagle, Clintwood and No. 2 Gas seams, and 27.5 to 30 per cent low volatile coals from No. 3 and 4 Pocahontas seams.

Coal is coked in three batteries of ovens which provide a total capacity of 1,128,000 tons of coke. One battery contains 75 under-jet ovens of vertical flue design, arranged for recirculation of waste gases. Each oven is 16½ to 19½ in. wide, 40 ft 6½ in. long inside the doors, 13 ft high, and takes an 18-ton coal charge. Each of the other batteries has 60 ovens of horizontal flue design, 17 to 19 in. wide, 35 ft 4 in. long and 11 ft 9 in. high, taking a 15-ton coal charge. All ovens are underfired with coke oven gas, consuming about 44 per cent of the total gas make.

Under normal operations, the large battery operates



General view of coke plant and by-product facilities. Coal bridge and car dumper can be seen in background.

on an 18-hr coking time and cokes 1800 tons of coal per day, 100 ovens being pushed each day. The two smaller batteries usually work on a 17½-hr coking time, and combine to push 165 ovens and coke 2475 tons of coal per day.

Quenched coke is spread on the coke wharf and, after cooling, is conveyed over the ovens to the screening station. Here it is crushed to −4 in. and screened. Furnace coke is sized to −4 in., +1½ in. Nut coke, running −1½ in., +¾ in., is also used in the furnaces but is charged separately. The breeze includes sizes under ¾ in., and is used in the sintering plant or boiler houses. From the screening station, coke is taken to the blast furnace bins by transfer cars.

Coke yield totals about 74.2 per cent, composed of 55.3 per cent furnace coke, 11.1 per cent nut coke and 7.8 per cent breeze. Other yields per ton of coal coked include 11,000 cu ft of gas, 7 gal of tar, 3 gal of light oil, and 5 lb of ammonia in the form of concentrated ammonia liquor. No sulphate is made in this plant. The benzol plant fractionates and refines light oil from the coke plant at the South Chicago plant as well as that made at the Harbor plant. A system is also provided for phenol recovery from still waste before its disposal.

Surplus coke gas to the extent of 26,000,000 cu ft per day is boosted to 5-psi pressure and distributed to various furnaces in the steel plant. Straight coke oven gas is used in the strip, sheet and tin mills. Coke gas is also distributed through the steel plant, and when the supply is inadequate, an equivalent mixture of natural gas and air is added.

BLAST FURNACES

Three blast furnaces, details of which are given in Table I, supply most of the iron used in the plant's open hearth furnaces. They are placed essentially in a row and are served by a common high line which carries three standard gage tracks, one for ore, one for coke and one for miscellaneous use. No. 1 and 2 furnaces are provided with eight ore bins each, and No. 3 furnace with 16 bins for ore and miscellaneous materials. Each of the smaller furnaces has five coke bins, while No. 3 has eight.

Ore and stone are drawn from the stock bins into scale cars, of which there are five: two of 10-ton, one of 30-ton and two of 40-ton capacity. The ore charge is made up of about 60 per cent Mesabi ores, 25 per cent Old Range ores and 15 per cent sinter. Ore and stone are charged by weight on all furnaces. Coke, which is screened as it flows from the bins into the skip cars, is charged by weight on No. 1 and No. 3 furnaces, by volume on No. 2 furnace

Furnace filling is done by motor-driven, double skip

No. 1 furnace has a 26-ft hearth and produces an average of 1400 tons of iron a day. Carbon hearth walls and bottom in this furnace are approaching 3,000,000-ton service.

TABLE I

Blast Furnace Data

	Indiana Harbor Works			South Chicago Works		
	No. 1	No. 2	No. 3	No. 3	No. 4	No. 5
Diameter of hearth, ft-in.	26-0	22-0	28-0	18-6	16-2	18-6
Diameter of bosh, ft-in.	29-6	24-9	31-3	22-6	19-6	22-6
Diameter of stockline, ft-in.	20-0	17-6	21-6	17-0	14-0	17-0
Height, iron notch to big bell, ft-in.	93-7	88-8 11/16	94-4	84-0	76-10 5/8	84-0
Height of crucible, ft-in.	13-9	11-7	12-3	11-9	10-6	11-9
Height of bosh, ft-in.	11-9	8-3	11-1 1/2	11-3	10-0	11-3
Height of straight section, ft-in.	7-6	14-1	6-10 1/2	11-0	6-0	11-0
Height of inwall section, ft-in.	54-5 1/4	45-10	56-3	41-0	38-10 1/2	41-0
Height, stockline section, ft-in.	10-1 3/4	10-8 11/16	10-4	7-2 1/2	10-9 1/8	7-2 1/2
Height, bottom to iron notch, ft-in.	4-0	1-9	2-6	2-0	1-3	2-0
Height, iron notch to cinder notch, ft-in.	4-8	4-8	4-8	4-7	4-3	4-7
Height, cinder notch to tuyeres, ft-in.	3-4	3-5	3-4	3-4	3-2	3-4
Working volume, tuyeres to stockline, cu ft	40,985	27,845	47,221	19,820	12,856	19,445
Bosh angle, deg-min-sec	81-31-44	80-32-0	81-41-23	79-55-0	80-32-0	79-55-0
Inwall slope, in. per ft	1.047	0.953	1.04	0.812	0.85	0.812
No. of tuyeres	18	12	20	10	12	10
Lining thickness, crucible, in.	36	37 1/2	36	31 1/2	31 1/2	31 1/2
Lining thickness, bosh, in.	31 1/2	27	27	31 1/2	27	31 1/2
Lining thickness, stack, in.	49 1/2	30	39 1/2	31 1/2	22 1/2	31 1/2
Lining thickness, throat, in.	48	32 1/2	36 3/4	40 1/2	30	40 1/2
Big bell diameter, ft-in.	15-0	13-6	16-0	13-0	9-6	13-0
No. and diameter of offtakes, ft-in.	(4) 5-0	(4) 4-0	(4) 5-6	(4) 4-0	(4) 3-0	(4) 4-0
No. of stoves	3	4	3	4	3	4
Stove diameter, ft-in.	21-11 1/2	24-0	26-0	22-0	22-0	22-0
Stove height, ft-in.	119-0	103-0	122-0	96-4 1/2	96-0	96-0
Checker openings, in.	1 15/16	5 1/4	1 15/16	4 1/2	3 1/2	5 1/4-4 1/2
Heating surface per stove, sq ft	186,115	75,836	251,350	70,000	44,000-95,588	60,863-70,000
Normal blast temperature, F	1050	1000	1150	1025	1050	1000
Normal furnace top temperature, F	350	280	400	300	375	310
Skip car volume, cu ft	250	165	300	160	120	165
Steam to blower, lb per hr, average	82,600	63,000	85,500	70,000	70,000	70,000
Blast volume, cfm, average	86,000	60,000	90,000	50,000	34,539	46,884
Blast volume, cfm, maximum	88,000	64,000	95,000	55,000	36,000	55,000
Normal blast pressure at tuyeres, psi	22	19	20	18.2	13.5	17.0
Normal top pressure, in. H_2O	125	50	55	35	35	35
Lb of ore per net ton of iron	2800	2701	3149	3750	4000	4050
Lb of sinter per net ton of iron	788	752	462	—	—	—
Lb of stone per net ton of iron	750	800	800	800	850	820
Lb of coke per net ton of iron	1770	1770	1760	1770	2080	2010
Lb of scrap charged per ton of iron	20	30	70	110	8	85
Lb of roll scale per ton of iron	160	200	90	—	—	—
Lb of open hearth slag per ton of iron	280	60	300	300	75	45
Daily iron production, net tons, average	1400	1000	1500	760	470	695
Daily iron production, net tons, maximum	1550	1100	1650	974	661	950
Lb of slag made per ton of iron	1050	1050	1050	1025	975	1035
Lb of flue dust made per ton of iron	230	270	250	200	275	255
Charging sequence	oocc/oscc/	occ/osc/	oocc/oscc/	oscc/oocc/	occ/oscc/	oosc/occ/

hoists. Each furnace has a revolving distributor top, with the bells operated by pneumatic cylinders. Automatic charging control and stock line recorders are installed on each furnace.

All furnaces are cooled by water-cooled hearth plates, with four rows of bosh plates in the hearth walls, six or seven rows of plates in the bosh, and 2 to 15 rows of plates in the stack above the mantle. Cast steel plates are set in the brickwork for stockline protection in all furnaces.

No. 1 furnace has a carbon hearth, installed with 30 in. of carbon block on the bottom and 27 in. of carbon block walls extending to about the center-line of the cinder notch. After a campaign of more than 2,500,000 tons, this furnace was given a stack reline but the carbon in the hearth was left intact, and is now approaching the 3,000,000-ton mark.

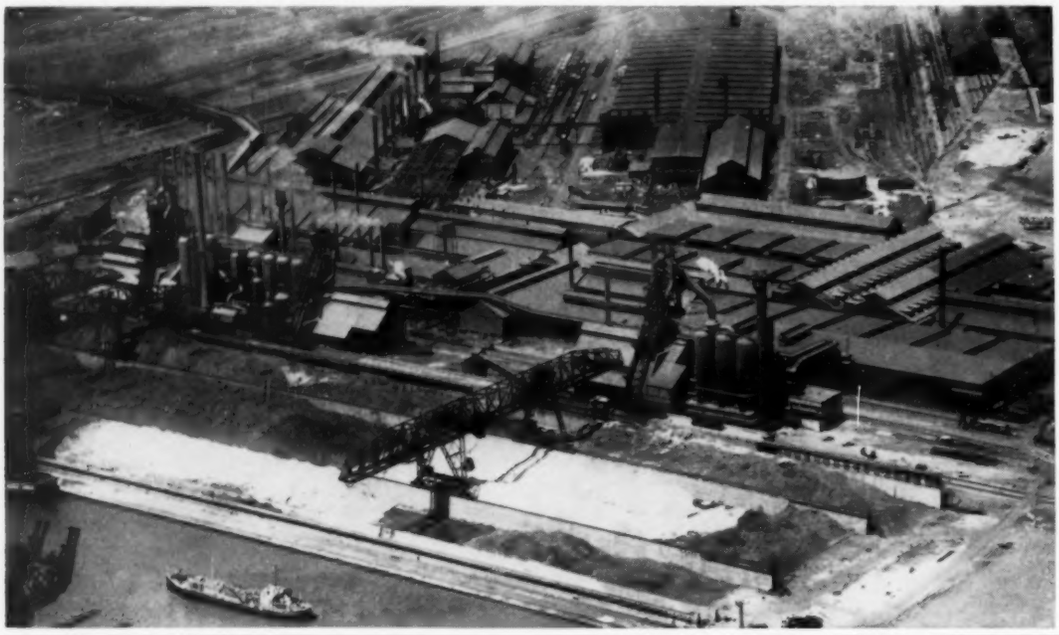
Blast for the furnaces is provided by five turbo blowers, operating on 200-psi steam. Two blowers are rated at 125,000 cfm, 35 psi; two at 60,000 cfm, 30 psi; and one at 55,000 cfm, 30 psi. Normally, the 125,000-cfm units serve No. 1 and No. 3 furnaces, with a 60,000-cfm unit on No. 2 furnace. The other two blowers, which serve as spares, may be operated in parallel if desired.

All hot blast stoves are of two-pass, side-combustion design, with pressure type, proportioning burners. A stove cycle of 4 hr on gas, 2 hr on blast is normal on the large furnace, and 6 hr on gas, 2 hr on blast on No. 2 furnace. Blast temperature is controlled by an automatic mixer valve on each furnace.

Each furnace has a dust-catcher and a wet washer, and No. 2 furnace also has a whirler between these two units. In addition, one large electrostatic precipitator

cleans the gas from No. 1 and No. 2 furnaces, while No. 3 furnace has two smaller precipitators. Gas is thus cleaned to 0.005 to 0.01 grains of dust per cu ft. The stoves consume 25 to 30 per cent of the total gas. Surplus gas is used to fire boilers, and a little is piped to the pits at the 46-in. blooming mill and to the 10-in. skelp mill furnace. Gas analyses run 13.7 per cent CO_2, 26.4 per cent CO and 2.8 per cent hydrogen, and develops 92.4 Btu per cu ft.

Dust-laden water from the three gas washers flows to two single-tray thickeners, 60 and 65 ft in diameter and rated at 6500 and 7000 gpm, respectively. The sludge from these thickeners is filtered, mixed with dry flue dust, coke breeze and a little fine ore, and sintered in two 72-in. traveling grate sintering machines, each with ten wind boxes. These two machines produce about 1000 tons of sinter per day.



This aerial view shows the canal in the foreground, paralleled by the ore yard and blast furnaces. Immediately behind the furnaces are the soaking pits, No. 1 blooming mill and pipe mills. No. 1 open hearth is at upper left, No. 2 at upper right, with merchant mills between.

Each furnace is tapped five times in 24 hours, the iron flowing into 150-ton mixer type ladles or 60-ton open top ladles. Basic iron is produced, ranging 0.80 to 1.20 per cent silicon, 1.30 to 1.5 per cent manganese, 0.25 per cent maximum phosphorus, and 0.050 per cent maximum sulphur. Normally, the iron is used as hot metal in the open hearths, but if necessary, iron may be cast into pigs on a double-strand pig machine rated at 35 tons per hour.

Slag analyses average as follows:

	Per cent
SiO_2	39.69
Al_2O_3	11.06
CaO	42.25
MgO	3.40
S	1.10

Part of the slag is sold to a processing firm and the remainder is used as fill.

These blast furnaces provide a total nominal capacity of 1,292,600 net tons of iron per year.

SOUTH CHICAGO PLANT

Additional capacity for the production of coke and iron is provided by the South Chicago plant, located on the Calumet River some seven miles away. The site includes about 200 acres. Coke is produced in two batteries of regenerative by-product ovens, each battery consisting of 35 ovens, 15 to 17 in. wide, 41 ft 6 in. long and 13 ft high. Each oven takes a 15.2-ton charge of coal. The ovens are heated by a combination of blast furnace gas enriched with coke oven gas.

The ovens normally work on a 16.7-hr coking time, 100 ovens being pushed per day, coking 1520 tons of coal per day. Coke yield averages about 74 per cent furnace coke and 4.5 per cent breeze. By-product yields run 10,500 cu ft of gas, 8 gal of tar, 2½ to 3 gal of light oil and 20 lb of ammonium sulphate per ton of coal coked.

By-products are recovered in a conventional plant, but no light oil fractionation is carried on here, the light oil being transferred to the benzol plant at the Harbor plant. Surplus coke oven gas is at present sold to a local utility company.

Three blast furnaces are also installed at this plant, details of which are given in Table I. All three furnaces are charged with conventional double skips. Bells on No. 3 and 4 furnaces are operated by hydraulic cylinders. Pneumatic cylinders work the bells on No. 5.

Blast for the three furnaces comes from four turboblowers, two rated at 45,000 cfm, two at 55,000 cfm. The blast is heated in eleven stoves, eight of which are center-combustion units, and three of side-combustion design. The latter are used on No. 5 furnace, the others on No. 3 and 4. One center-combustion stove is arranged so that it may be used on either No. 4 or No. 5 furnace.

Gas leaving the furnaces passes through dust catchers, where the entrained dust is reduced from about 13 grains to 1.5 grains per cu ft, then through wet washers which bring the dust content to about 0.15 grains per cu ft. An electrostatic precipitator further cleans part of the gas for use in heating the coke ovens. Water from the washers is put through a 90-ft diameter, single tray thickener. About 23 per cent of the blast furnace gas is used by the hot blast stoves, the surplus being used for underfiring the coke ovens and for steam generation.

Two open hearth shops totaling 17 furnaces provide a capacity of 2,676,000 net tons of open hearth ingots per year.

Each furnace is tapped every six hours into 150-ton mixer type ladles or 40-ton open top ladles. In general, No. 3 furnace produces basic iron which is used as hot metal in the open hearth furnaces at the Harbor plant. No. 4 and 5 furnaces produce merchant iron running 1.0 to 3.5 per cent silicon, 0.50 to 1.25 per cent manganese and 0.13 to 0.90 per cent phosphorus. This iron is put over a four-strand pig machine. Some of the hot metal is used in the plant's foundry.

Slag from the furnaces flows into ladles and is taken to a dump. Some slag flows directly from No. 5 furnace to a plant producing light weight aggregate.

The South Chicago plant provides a total annual capacity for 410,000 tons of coke and 684,000 tons of iron. The plant has ore and coal storage approximately 2700 ft long × 350 ft wide, lying along the Calumet River and served by four unloader bridges.

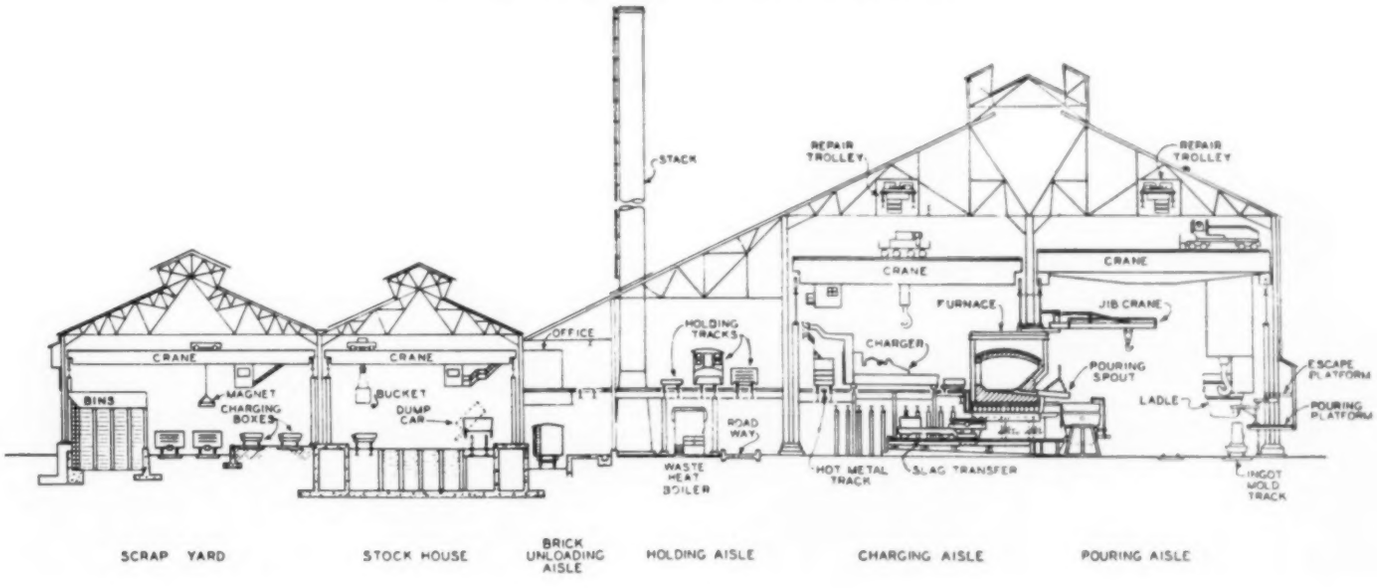
NO. 2 OPEN HEARTH SHOP

An important step in the recent expansion of the Harbor plant is a modern open hearth shop containing eight 275-ton furnaces. These furnaces have overall dimensions of 87 ft × 25 ft, and are spaced on 108-ft centers except for No. 4 and No. 5 furnaces, which are spaced at 162-ft centers.

Bath dimensions run 54 ft × 15 ft 10½ in. at the foreplate line. Furnace bottoms are built up of 1 in. of ganister, 7½ to 12 in. of first quality firebrick, 9 to 12 in. of chrome brick, 20 in. of rammed sub-hearth and 9 in. of sintered magnesite. Basic brick are used in front and back walls and in port walls. All of the furnaces have sloping backwalls.

Furnace roofs have a span of 22 ft 7 in. and are built of 16-in. silica brick with a 20-in. rib every fourth course.

Section through No. 2 open hearth department.



Open hearth charges at the Harbor plant contain 48-55 per cent hot metal.

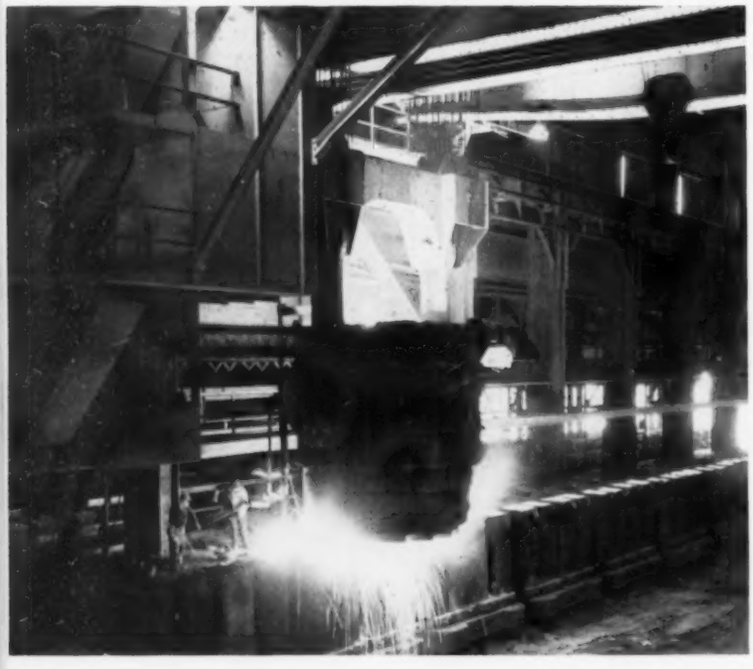
A 22 ft 9 in. roof radius results in an arch rise of 3 ft. The main roof section is 52 ft long, the slopes rise 3 ft 3 in. in a length of 7 ft 11 in., and port roofs are 9 ft long.

Port ends are 21 ft wide and contain two downtakes 8 ft 3 in. long × 5 ft 7½ in. wide, affording about 100 sq ft at each end of the furnace. Slag pockets are 18 ft 6 in. × 21 ft, and are 9 ft 6 in. high to the top of the fantail bridgewall.

There are two regenerator chambers at each end of the furnace, each chamber 13 ft 7½ in. wide × 30 ft 3 in. long × 24 ft 4½ in. high. Checkerwork is built to a height of 14 ft, of 18 in. × 6 in. × 3 in. brick, forming flues 7½ in. square.

The furnaces are fired with bunker C fuel oil through steam-atomizing burners of 800 gphr maximum capacity. Burner ports are slanted toward the front wall, the inner end being 4½ in. off center.

To handle the wide range of steels produced, a variety of ingot sizes and types is required.



Each furnace has an individual operating control house containing instruments and automatic controls for oil flow, fuel-air ratio, atomizing steam flow, furnace pressure and furnace reversal.

Forced draft is provided for each furnace by a 23,000 cfm, 4.75 in. water pressure fan. Each furnace is also equipped with a fire-tube waste heat boiler producing about 21,000 lb of steam per hr at 250 psi pressure. An 85,000-cfm fan supplies induced draft. Stacks are 225 ft high.

Hot metal comes from the blast furnaces in 150-ton mixer type ladles, from which the iron is poured into 100-ton open top ladles and taken to the furnace by cranes and transfer cars. The furnaces operate on charges containing 48 to 55 per cent hot metal.

A wide range of carbon and alloy steels is produced, of 0.03 to 0.25 per cent carbon. Flux consumption per ton of ingots averages 109 lb of limestone, 8 lb of burnt lime and 3 lb of fluorspar. Heat time runs about 10 hr, charge-to-tap, and production averages about 26 tons per furnace-hour. Fuel consumption averages 2,860,000 Btu per ton of ingots.

Steel is tapped into molds of various types and sizes, including 28 × 28 × 74 in., 26 × 58 × 68 in., 30 × 42 × 71 in., 32 × 46 × 71½ in., and 29½ × 58 × 70½ in. Molds are usually sprayed with a graphite solution.

The furnaces are designed for back and front flushing, with a cinder car traveling over a track under the furnace between the regenerators. Slag is run into a cinder pot and used for fill in various parts of the plant site.

This open hearth unit includes seven parallel structures. See Table II. The main unit consists of four adjacent bays: the brick unloading bay, the holding bay, the charging aisle and the pouring aisle. A separate mold preparation building parallels the pouring aisle.

The lower level of the brick-unloading bay has a depressed track which permits unloading brick on pallets by lift trucks, which then carry them along the wharf to an elevator. The upper floor of this bay carries a track from which miscellaneous refractory in hopper cars may be dumped into bins beneath the track. A loading machine on the lower floor then removes these materials for transport to a refractory repair area at the west end of the shop. Wet and dry pans, ladle repair pit, and stopper rod press and oven are installed here.

The holding bay contains three tracks which connect to the charging buggy track by a spur for every two furnaces.

In the main building, columns are spaced on 108-ft centers on both sides of the charging and pouring bays, permitting better track arrangement and leaving free areas for control houses, material bins, etc. The pouring aisle is unusually wide, permitting a roadway the full length of the building between ladle stands and slag tracks. Roadways are also provided along the lower level of the holding bay and across the building between No. 4 and 5 furnaces. A ramp for autos and trucks comes up to the east end of the charging floor. All material enters this open hearth shop at the west end.

Along the main building at the west end is the stock house containing large bins for storage of dolomite, limestone, ore, fluorspar, etc. Adjacent to this is the scrap yard with two depressed tracks for incoming cars and two tracks for drags of charging boxes.

TABLE II

Open Hearth Buildings and Cranes

Building	Length, ft-in.	Width, ft-in.	Cranes	
			No.	Capacity, tons
No. 2 Shop				
Scrap yard	864-0	89-5	3	15
Stockhouse	432-6	70-0	2	15
Brick unloading bay	1134-0	32-0	—	—
Holding bay	1215-0	60-0	—	—
Charging bay	1296-0	85-0	3	150/40
			3*	12
Pouring bay	1134-0	85-0	3	350/60/20
Mold yard	594-0	88-0	2	25/10
Stripper building	432-0	114-0	2	50/15
No. 1 Shop				
Scrap yard and mold storage	651-0	103-1½	2	15/5
			1	10
Leanto	992-0	15-0	—	—
Charging bay	992-0	83-4	3	150/40
			3*	10
Pouring bay	992-0	64-8	3	300/60
Stripper building	260-0	54-0½	2	150
Raw material building	270-0	63-0	1	15
Mixer building	132-0	87-8	1	100

*Floor type charging machines.

NO. 1 OPEN HEARTH SHOP

The older open hearth shop contains nine open hearth furnaces which have been gradually enlarged until they now tap 220-ton heats. Because of this redesigning, furnace dimensions vary somewhat, running 76 ft 6 in. and 83 ft overall length, and 19 ft in width, with hearths 42 ft × 16 ft and 51 ft long × 14 ft wide. The four original furnaces are built on 100-ft centers, the later ones on 110-ft centers.

Furnace bottoms range 37 to 45 in. in thickness, composed of varying combinations of fire clay brick, chrome brick, magnesite brick and rammed plastic refractories. Basic brick are used in front and backwalls. All furnaces except one have sloping backwalls.

Furnace roofs are of silica brick, 16 in. thick with 20-in. ribs every fourth course. On the later design, the main roof section is 52 ft 9½ in. long, with a sloping section 7 ft 3 in. long and a horizontal port roof 7 ft 10⅝ in. long at each end. The width of the main roof between skewbacks is about 22 ft.

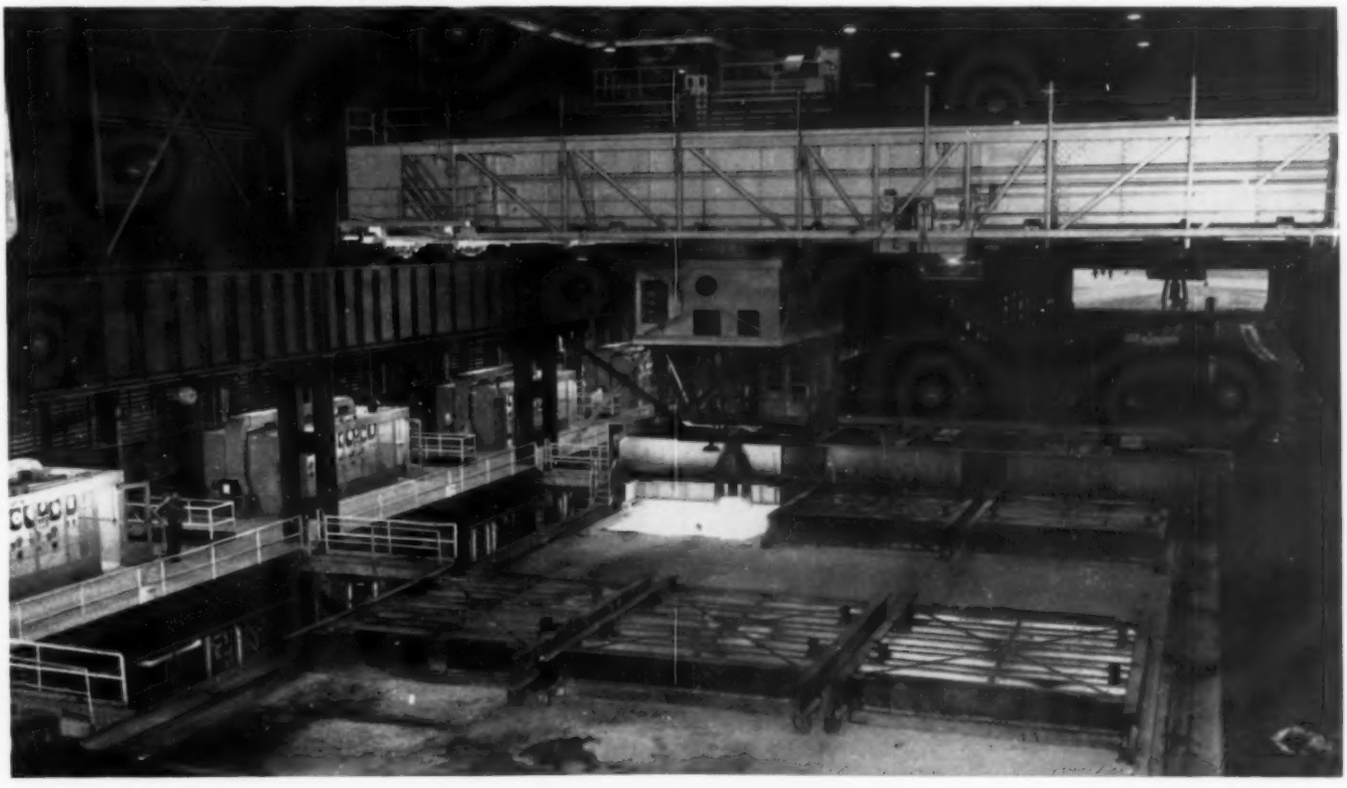
Two downtakes approximately 7 ft long × 5 ft wide at each end of the furnace provide an area of about 69 sq ft, and lead into a slag pocket 15 ft 2 in. long × 14 ft 6 in. wide.

Regenerators are constructed in double chambers at each end of the furnace. On the original four furnaces, these chambers are separate, 13 ft and 7 ft in width respectively. On the other five furnaces, the two chambers are side by side, with a common separating wall. These chambers are 16 ft 2½ in. and 12 ft 2½ in. wide, respectively. All regenerators are 29 ft 11 in. long and contain checkerwork about 11 ft high. Checkers are built of 13½ × 4½ × 3 in. brick in basket weave construction. The newer furnaces have slightly over 10,000 cu ft of checkerwork on each end.

Insulation is provided on the slag pockets, fantails and regenerator chambers.

From the regenerators, waste gases flow through waste heat boilers and on to stacks 7 ft in diameter × 150 ft high. The four original furnaces are equipped with water-tube boilers, the other five with fire-tube units. Each boiler generates 18,000 to 20,000 lb of steam per hr at 250 psi pressure.

Eighteen recuperative pits serve the new blooming mill. Automatic controls for each row are mounted in the control houses along the heater's platform.



The furnaces in No. 1 shop are fired with fuel oil. Provisions are made to burn gas also, but at present none is available. All of the furnaces are equipped with automatic controls on furnace pressure, fuel input, fuel-air ratio and furnace reversal, as well as with roof temperature indicators. Air is supplied to each furnace by a 15,000-cfm forced draft fan.

Hot metal from the blast furnaces is brought to a 600-ton mixer at the west end of the shop, and is subsequently transferred to the furnaces by ladle, transfer car and overhead crane. Furnace charges contain about 48 per cent hot metal.

Heats average about 11 hr, tap-to-tap, giving an average production of 20 tons per furnace-hour. A wide variety of steels is produced in carbon and alloy grades. Flux consumption averages 130 lb of limestone, 10 lb of burnt lime, and 5 lb of fluorspar per ton of ingots produced. Slag, produced to the extent of about 12 per cent volume, is put over a dump and subsequently processed by mobile cranes for consumption in the blast furnaces.

Steel is poured into hot topped molds 24 × 26 × 75 in., open top molds 26 to 30 × 28 to 58 × 72 to 80 in., or bottle top molds 27 × 27 × 80 in. or 32 × 46 × 80 in. Before teeming, molds are sprayed with a graphite solution.

45-IN. BLOOMING MILL

Primary rolling mills now consist of two blooming mills, one a new 45-in. unit started up in 1953, the other an older 46-in. unit.

Heating facilities for the 45-in. mill consist of six rows of recuperative pits of three holes each. Each hole, 19 ft long × 15 ft wide × 14 ft 6 in. deep, is provided with a refractory recuperator, capable of heating air for combustion to temperatures of 1300 to 1500 F. The air is supplied by a 13,000-cfm fan for each row of pits.

The pits are fired with coke oven gas or an equivalent mixture of natural gas and air, or with fuel oil, introduced through two burners near the top of the pit at diagonal corners. Complete control equipment provides automatic regulation of fuel-air ratio, temperature and furnace pressure. Temperature of ingots charged to the pits varies somewhat with track time, but in general averages about 1400 F. Fuel consumption averages 810,000 Btu per net ton of ingots. The 18 pits are served by two cover cranes. Two tracks for incoming ingots extend along the charging side of the pits.

The pits are operated with dry bottoms of burnt dolomite.

Ingots are handled into and out of the pits by two 25/15-ton pit cranes of 107-ft span. Heated ingots from the pits are moved by ingot buggy to the mill receiving table. The buggy is hauled to and from the mill by cables which are wound and unwound on two winches. One winch is located at the far end of the ingot buggy track, the other in the basement of the mill motor room. Control of the 100-hp winch motors is coordinated to maintain some tension on both cables at all times, the relative cable pulls being varied to effect acceleration and deceleration. Ingot buggy movement is under the control of an operator in a pulpit near the receiving table. Having selected the pit position desired, the operator merely pushes a button to start a cycle of movement. Speed attained by the buggy is automatically adjusted to the distance to be traversed.

Tables preceding the mill extend for 132 ft and are driven in five sections through line shafts and gears by 230-volt d-c motors, as noted in Table III.

Between the receiving table and the mill approach table is an overhead suspended scale and ingot turning device, designed to handle ingots up to 30 tons in weight.

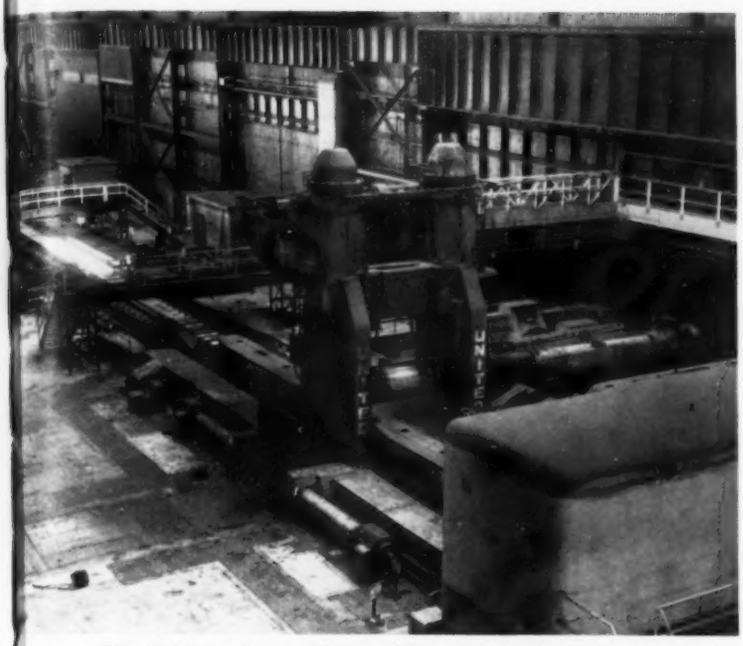
The 45-in. mill is a two-high, high-lift reversing unit, with closed top housings having posts 21 in. × 34 in. The cast alloy steel rolls have a body 115 in. long × 45 in. diameter, and operate in fabric bearings. The top roll is balanced by a counterweight. Mill screws, 18 in. in diameter with 2¼-in. pitch, are driven by two 200-hp, 420 to 840 rpm d-c motors at speeds that afford a roll lifting speed up to 35.5 fpm. A maximum lift of 72 in. is available.

Double rack type cast steel sideguards are installed on each side of the mill, driven through pinions and speed reducers by four 150-hp, 460 to 600 rpm d-c motors. Manipulator fingers are installed on the entry side of the mill. They are driven by a 150-hp, 460-rpm motor. Front and back mill tables are each driven by

TABLE III

45-in. Mill Table Layout

	Rollers			Motor		Table speed, fpm
	No.	Diam, in.	Spacing, in.	Hp	Rpm	
Ingot receiving table	6	18	29	75	515	212
Scale approach table	8	18	29	100	485	313
Ingot scale table	12	18	29	150	460	405
Mill approach table	12	18	29	150	460	405
Front mill table	14	20	29	(2)150	460/920	460/920
Back mill table	14	20	29	(2)150	460/920	460/920
Mill runout table	12	18	29	150	460	405
Edger approach table	8	18	29	100	485	313
Edger delivery table	12	18	29	100	485	313
Scarfer approach table	11	18	29	100	485	313
Scarfer delivery table	11	18	29	100	485	313
Shear approach table	8	18	29	100	485	313
Shear entry table	9	18	29	100	485	313
Pull-back table	9	16	18	35	575	304
Shear gage table	9	16	24	50	550	301
Slab scale table	12	16	24	75	515	306
Tilting table	13	16	20	50	550	297



No. 2 blooming mill is a 45 in. high-lift unit used principally for rolling slabs for the hot strip mill.

two 150-hp, 460 to 920-rpm motors. Feed rollers on each side of the mill are driven by a 50-hp, 460 to 920 rpm motor.

The mill itself is driven in twin drive arrangement through counterbalanced spindles by two 5000-hp, 750-volt, 40 to 80 rpm d-c motors under adjustable voltage control. Each motor is connected to the roll it drives by a spindle 23 in. in diameter. A maximum delivery speed of 940 fpm is available.

Power is supplied to these motors by a motor-generator set consisting of four 2250-kw, 750-volt, d-c generators, a 13 ft 8 in., 143,000-lb steel plate flywheel, and a 7000-hp, 11,500-volt, 514-rpm induction motor.

All auxiliaries of the 45-in. mill, including front and back mill tables, feed rollers, screwdowns and sideguards, operate under adjustable voltage control, their drives receiving power from two motor-generator sets, each consisting of seven 250-volt, d-c generators driven by a 1000-hp, 2300-volt, 1200-rpm synchronous motor.

The mill drive motor, main motor generator set, auxiliary sets, exciters, control equipment, switchgear is housed in an adjacent motor room. Large rotating units are cooled by air pulled from the room down through the machines into the basement, where the air is cooled and returned to the motor room. Make-up air for the ventilating system is drawn through electrostatic precipitators located in balconies at both ends of the motor room.

Following the mill stand at a distance of 94 ft 8½ in. is a 40-in. vertical edging stand, designed to give the slab a single finishing pass. This unit is driven by an 800-hp, 2300-volt, 360-rpm synchronous motor through gearing giving a total reduction of 11.2 to 1. Edger rolls operate at 32.1 rpm, with a roll face speed of 337 fpm. They are adjusted by a 25-hp, d-c motor.

Following the edging stand at a distance of 135 ft 7½ in. is a 1500-ton up-and-down cut shear designed to cut sections up to 10 in. × 60 in. It is driven by two 500-hp, 375 to 700 rpm, d-c motors under adjustable voltage control, starting and stopping with each stroke of the shear. A motor-operated shear gage measures lengths as desired in a range of 5 to 20 ft. A pullback table permits crops to fall into a skip car in the crop pit. When filled, the skip car is pulled up and emptied into a pit in the crop and scale building, and then loaded into cars. This building also contains a scale pit into which scale from the mill is flushed, to be subsequently removed by bucket and crane, and loaded into railroad cars.

The slab shear is served by a motor-generator set consisting of five 250-volt d-c generators driven by a 1750-hp, 2300-volt, 900-rpm synchronous motor. Two 500-kw generators supply the two shear motors, while two 200-kw and one 100-kw generators supply the shear tables.

Slabs leaving the shear pass over a tilting table which piles them on either of two transfer cars with two cars attached. These cars move over a track at right angles to the mill line, transporting the mill product into an adjacent slab yard.

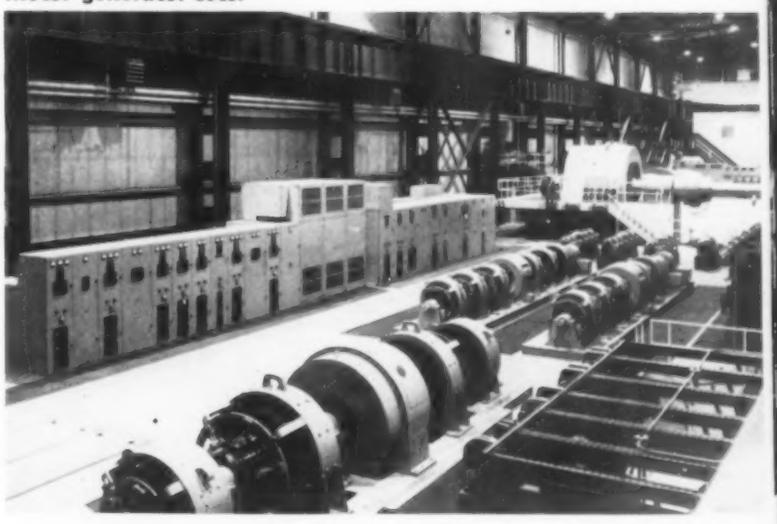
The 45-in. mill rolls slabs only, reducing ingots ranging 25 to 32 in. in thickness, 42 to 58 in. in width and 18,300 to 30,000 lb in weight to slabs 23 to 52 in. wide and 4 to 7 in. thick. It averages about 266 net tons per hr, but has rolled as much as 340 tons in one hour and 2400 tons in an eight-hour turn.

This mill is housed in a separate group of buildings consisting of a stripper building 432 ft × 114 ft, served by two 400-ton stripper cranes; a soaking pit building 543 ft × 114 ft with a 20-ft leanto housing pit control panels; the mill building proper 575 ft × 100 ft 8½ in., served by a 125/25-ton crane and a 25/15-ton crane. These buildings lie end to end. Along one side of the mill building is a crop and cinder building, 400 ft × 71 ft, containing a 15-ton crane. At the other side of the mill building is the motor room 375 ft × 65 ft, with a 125/25-ton crane, and a transfer and roll shop 300 ft long × 65 ft, served by a 40-ton crane. Adjoining the transfer building is the slab yard, 575 ft long × 117 ft wide and served by two 25/15-ton overhead cranes and two 15-ton semi-gantry cranes.

46-IN. BLOOMING MILL

The 46-in. mill, which was installed in 1947, is served by 12 rows of soaking pits. Eight rows are of regenera-

No. 2 blooming mill is driven by two 5000-hp motors in twin drive arrangement. In the foreground are auxiliary motor-generator sets.



tive type, each row containing four holes 6 ft 10⅞ in. wide × 12 ft long × 8 ft 3 in. to 9 ft 9 in. deep. Two more rows each of four holes 7 ft wide × 14 ft 6 in. long × 11 ft deep, are of recuperative type, with silicon carbide tubular recuperators. Another recuperative row contains four holes 6 ft 6 in. wide × 14 ft 6 in. long × 11 ft deep. One more row of recuperative design contains two pits 11 ft wide × 22 ft long × 11 ft 9½ in. deep. The last two rows have refractory recuperators.

These pits provide a total hearth area of 4350 sq ft. They are fired with a mixture of blast furnace gas and coke oven gas of 118 Btu per cu ft. These gases are mixed in a station at the blooming mill.

The regenerative pits are equipped with automatic reversal on a time cycle. The recuperative pits have automatic controls on temperature, fuel-air ratio and furnace pressure.

Ingots are charged to the pits at temperatures ranging from atmosphere up to 1400 F. Fuel consumption averages 1,970,000 Btu per ton of ingots.

These pits are served by two 20-ton pit cranes and one 10-ton pit crane. An ingot buggy carries the heated ingots to the tables, which extend for some 150 ft to the mill. An ingot scale and turner is installed in this line, preceding the mill.

The 46-in. mill is a two-high reversing stand, with housing posts 19½ in. × 34 in. Rolls are of cast steel, with bodies 100 in. long × 39 in. in diameter. The top roll is balanced hydraulically. Roll necks run in composition bearings. Babbitted bearings are provided in the pinion stand.

This mill is driven through double helical mill pinions of 46-in. pitch diameter and 50 in. face by an 8000-hp, 700-volt, 50 to 120-rpm, d-c motor under adjustable voltage control. This motor draws power from a flywheel motor-generator set composed of two 3000-kw, 700-volt, d-c generators and three small exciters driven at 360 rpm by a 5000-hp, 2200-volt, induction motor.

The mill has a delivery speed up to 1200 fpm.

Mill screws are 15 in. in diameter with 2-in. pitch, and are driven by two 150-hp motors so as to give a lifting speed of 19.16 fpm. A maximum lift of 58 in. is available. Screwdown motors are operated under adjustable voltage control, drawing power from a 150-kw motor-generator set.

Sideguards on each side of the mill are driven through racks and pinions by four 100-hp motors. Manipulator fingers, driven by a 150-hp motor, are provided on the entry side of the mill. Front and back mill tables are each driven by two 100-hp motors, and a 50-hp motor drives the feed rolls on each side of the mill. All of these drives operate under magnetic control.

The 46-in. mill produces slabs ranging from 29 in. × 7 in. to 52 in. × 4 in., and blooms from 7 in. × 7 in. to 12 in. × 8 in. About 78 per cent of the tonnage is in blooms, 22 per cent in slabs. The mill averages about 185 tons rolled per hour, but has rolled as much as 250 tons in an hour, 2001 tons in an 8-hr turn, 5024 tons in a day and 131,075 tons in a month.

About 110 ft beyond the mill is an automatic scarfing machine used only for blooms.

Leaving the mill, the steel may follow either of two courses. Slabs are moved over a chain transfer to another table line about 35 ft to the left. This line contains a slab shear driven by two 275-hp motors and capable of cutting sections up to 54 in. × 11 in. After shearing, the slab progresses to a push-off and slab piler.

Blooms leaving the scarfer proceed straight ahead to a bloom shear which is driven by a 125-hp motor.

21-IN. BILLET MILL

In line with the 46 in. bloomer, and approximately 300 ft distant is a 21 in. billet mill consisting of ten two-high stands and three vertical edgers. Details of this mill are given in Table IV.

TABLE IV
21-in. Billet Mill

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Roll rpm
	Diameter	Body length		
28-in. billet mill				
No. 1	27¼	60	—	5.91/ 9.56
No. 2	28¼	60	18-0	7.55/12.22
No. 3	27¼	60	16-0	9.62/14.43
Edger	19	12	10-0	15.16/31.84
No. 4	28¼	60	10-0	13.05/19.58
No. 5	22⅛	52½	20-0	19.95/25.17
Edger	19	12	9-6	23.88/50.15
No. 6	22	52½	9-6	28.34/35.77
Edger	19	12	9-6	35.56/74.69
No. 7	22	52½	9-6	39.99/50.46
No. 8	22	52½	15-0	56.53/71.33
No. 9	21¾	52½	15-0	77.95/98.36
No. 10	21¾	52½	14-0	106.80/134.77

The first two stands are driven by a 2500-hp, 34 to 35 rpm, 650-volt, d-c motor; the next two, by a similar motor but of 300 to 450 rpm; and the last six stands by a 6000-hp, 317 to 392 rpm, 2200-volt induction motor. Each edger is driven by a 200-hp, 250 to 525 rpm, 230-volt, d-c motor.

The two 2500-hp motors draw power from a motor-generator set composed of two 2000-kw, 650-volt, d-c generators driven by a 5600-hp, 514 rpm, 2200-volt synchronous motor. Each generator is connected individually to one 2500-hp motor. The 600-hp a-c motor operates under a Kraemer control system, embodying a 900-kw, 249 rpm, 315-volt rotary converter and an 1150-hp, 315-volt d-c motor.

This mill receives blooms ranging 8¼ to 12 in. in width, 7½ to 8 in. in thickness, 30 to 44 ft in length, and 8700 to 11,900 lb in weight. It produces 1¾ to 7-in. square billets and flats from 5 × 2½ in. to 12 × 3¾ in. Delivery speed ranges 610 to 770 fpm. The average rolling rate is 116 tons per hour, but has produced as much as 1511 tons per 8-hr turn.

A steam-operated flying shear, designed to cut sections up to 25 sq in. of hot steel, is located 21 ft 6 in. after the last mill stand. Approximately 100 ft farther along the table is an up-and-down cut shear, which is followed by three cooling beds 30 ft wide × 75 ft wide.

Steel from this mill is used principally as billets for rerolling in the merchant mills or as slabs for rerolling in the 10-in. skelp mill

21-IN. SKELP MILL

Paralleling No. 1 bloomer and billet mill line about 40 ft away, and connected to it by a transfer is a 21-in.

TABLE V
21-in. Skelp Mill

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Roll rpm
	Diameter	Body length		
1	23 3/8	25	—	5.998/11.27
2	22 1/2	25	9-0	8.46/15.9
3	24 1/4	25	9-0	12.45/24.4
Edger	19 1/2	12	8-0.3	18.45/35.36
4	21 1/2	25	7-11.7	24.49/46.98
5	20 5/8	25	10-0	34.24/65.68
Edger	18	10.5	9-11.83	65.36/125.36
6	20 5/8	25	10-0.17	45.75/87.75
7	21 1/2	25	10-0	57.43/110.14
Edger	18	10.5	10-0	89.79/179.58
8	21 1/2	25	10-0	85/165
Edger	18	4	10-7	111.46/323.25
9	21 1/2	25	10-7	85/165
10	21 1/2	25	10-7	85/165

continuous skelp mill. This mill has ten stands and four edgers. Details are given in Table V.

The first three stands of this mill are driven by a 3600-hp, 156 to 290 rpm, 2200-volt motor, and the next four stands by a 7500-hp, 134 to 254 rpm, 2200-volt motor. Both of these drives operate under a modified Kraemer system. Three motor-generator sets, each consisting of two 1700-kw, 600-volt generators and a 4400-kva, 2200-volt synchronous motor, are used in this control, and in addition furnish power to the three 2000-hp, 85 to 165 rpm, 600-volt, d-c motors driving the last three mill stands. The first edger is driven by a 200-hp, 300 to 900 rpm motor, the third edger by a 250-hp, 175 to 350 rpm motor, and the fourth edger by a 100-hp, 500 to 1450 rpm motor, all 230-volt d-c. The second edger is driven through gearing from the 7500-hp mill drive motor.

Hydraulically operated loopers are installed to take up slack in the skelp between mill stands.

This mill takes slabs from the 46-in. mill, ranging 14½ to 22½ in. wide, 4 to 4½ in. thick, 34 to 54 ft long, and about 11,900 lb. At delivery speeds of 433 to 930 fpm, it can turn out flats 18½ to 22¾ in. wide × 0.25 to 0.50 in. thick, and coiled skelp up to 17½ in. wide and 0.210 to 0.325 in. thick. At present its product is skelp in widths of 15¼ and 17¼ in. The mill averages 111 tons per hour, but has reached 1313 tons in an 8-hr turn.

Product from the skelp mill may be cut into lengths on a flying shear and taken over two 30 ft × 65-ft cooling beds, or it may be put through oscillating vibrators onto apron conveyors, forming the so-called "Christmas candy" before entering vertical reels.

Steel rolled on this mill is used principally in the continuous butt-weld pipe mills.

10-IN. SKELP MILL

Skelp production from the 21-in. mill is augmented by smaller sizes from a 10-in. skelp mill. Slabs from the 46-in. bloomer and billet mill, ranging 5 to 12 in. wide, 2½ to 2¾ in. thick, 28 to 35 ft long and 1300 to 3400 lb, are heated in a continuous side-charge, side-discharge furnace, 38 ft wide × 60 ft 6 in. long. This furnace is fired with fuel oil or gas, and has a metallic recuperator.

The 10-in. mill is a continuous train, arranged as given in Table VI.

The first two stands of this mill are driven by a 600-hp, 250-volt, 300 to 600 rpm, d-c motor. No. 1 edger is driven by a 100-hp, 250-volt, d-c motor. The next five stands and No. 2 edger are driven through gearing by a 2000-hp, 234 to 360 rpm, 2200-volt, a-c motor. The third edger has a 160 to 200-hp, 250 to 525 rpm, 250-volt, d-c drive. The last three horizontal roll stands are driven through belting by a 2000-hp, 161 to 230 rpm, 1228 to 2200-volt, a-c motor, and the last edger by a 50 to 60-hp, 250-volt, d-c motor.

All roll necks in this mill run in composition bearings, and bronze bushings are applied in the pinions and gearing.

TABLE VI
10-in. Skelp Mill

Stand	Roll size, in.		Distance from preceding stand, ft-in.	Roll rpm
	Diameter	Body length		
0	13	18	8-0	13.74/27.48
1	13.5	18	6-0	19.19/38.37
Edger	11.0	7	5-1 3/4	22.02/54.02
2	11.5	15	4-10 1/4	26.52/40.8
3	9.5	15	4-3 11/16	45.57/70.1
Edger	10.25	4	4-0	42.69/65.65
5	9.75	15	3-8 3/4	64.97/99.86
6	10.0	15	3-3 1/2	91.7 /141.1
7	10.5	15	3-5 15/32	119.9 /184.5
Edger	11.5	4	20-3 1/2	81.2 /170.51
9	10.0	15	15-0	187.6 /268
10	10.125	15	8-6	230.8 /329.5
Edger	12.375	4	4-0	133/400
11	10.25	15	7-6	277/395.9

Skelp in widths of 4 15/16 to 12 in. and gages of 0.104 to 0.295 in. is delivered from the 10-in. mill at speeds of 743 to 1065 fpm and proceeds to the coilers. The reels are of vertical type, with twist guides, vibrators, vertical shears and apron conveyors. The reels form coils up to 46 in. outside diameter.

This mill averages 82 tons rolled per hour, but has reached an 8-hr turn output of 857 tons. Product is principally coiled skelp to be used in the continuous butt-weld pipe mills.

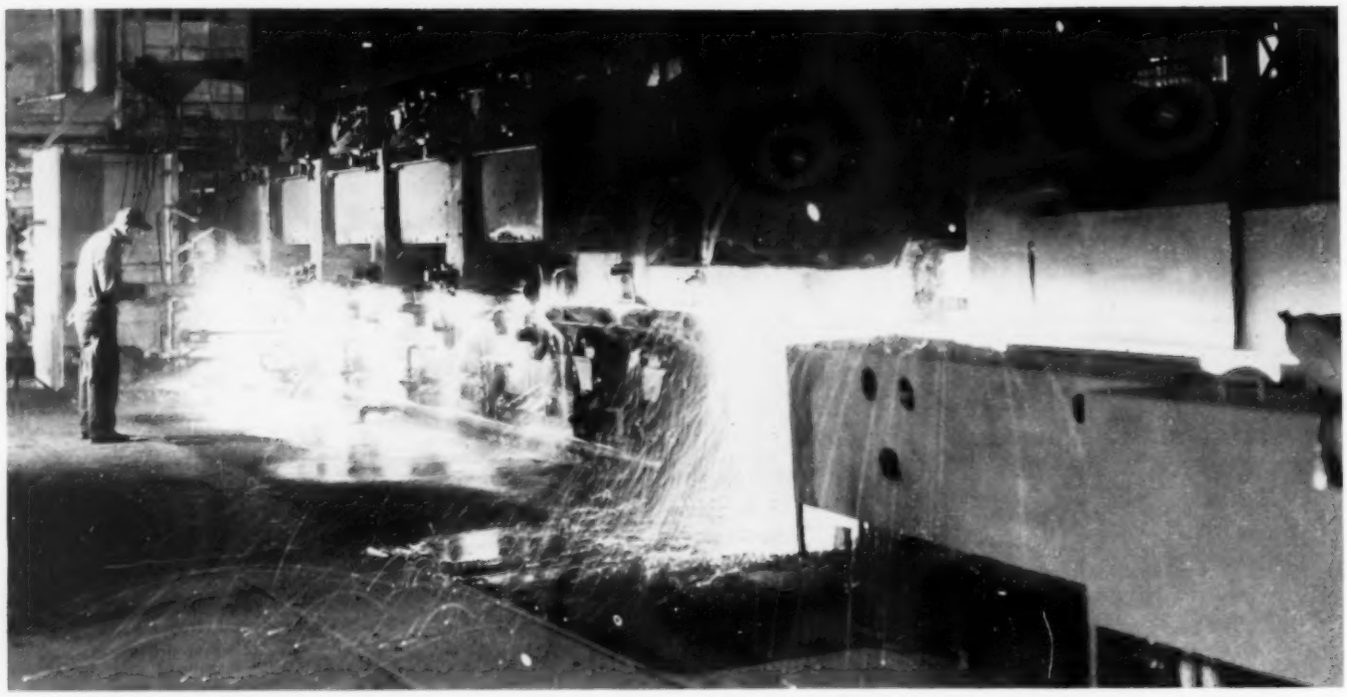
PIPE MILLS

Pipe is made in two continuous butt-weld pipe mills with a combined annual rating of 348,000 tons. No. 1 mill produces pipe in sizes ½ to 1½ in. diameter in a speed range of 107 to 714 fpm.

Bevel-edge skelp comes to the furnaces in coils, and ranges from 4.937 in. × 0.109 in. for ½-in. standard pipe to 8.625 in. × 0.145 in. for 1½ in. standard. The skelp is uncoiled through a roller leveler, flash welder and pinch rolls, and passes in single strand through a heating furnace of 146 ft 6 in. overall length. The furnace is equipped with six tubular recuperator chambers and three fans, and is fired with gas or fuel oil.

Leaving the furnace, the heated skelp passes between air jets and then through the mill, which consists of 12 sets of forming, welding and sizing rolls, alternately vertical and horizontal.

An oxygen jet is played on the skelp edges between the first and second pairs of rolls to intensify the temperature of the edges. The entire mill is driven by a single 125 to 150 hp, 300 to 1200 rpm, 230-volt, d-c motor,



Two continuous butt-weld pipe mills provide an annual capacity of 348,000 tons, in sizes ranging ½ in. to 4 in.

operated under adjustable voltage control. At the end of the mill is an automatic flying hot saw, synchronized with the mill.

The pipe next passes over a 52 ft 6 in. × 7-ft intermediate cooling bed, through descaling rolls, and over another cooling bed 72 ft × 30 ft. From this bed, pipe is discharged into a cradle from which they are removed by overhead crane.

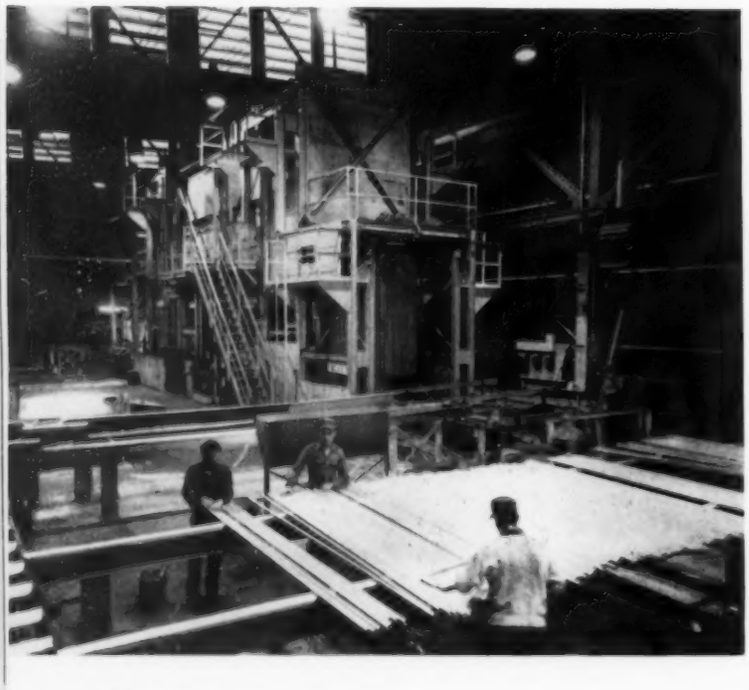
No. 2 mill is likewise a conventional continuous butt weld mill, but is designed for pipe 1 to 4 in. in diameter. Skelp sizes range from 6.5 in. × 0.133 in. for 1-in. standard pipe up to 17.5 in. × 0.237 in. for 4-in. standard pipe. The heating furnace is 160 ft 5½ in. long and has four recuperators. The mill consists of only ten pairs of rolls, alternately vertical and horizontal. In this unit, each pair of rolls is driven by a 25-hp, 450 to 1800-rpm, 230-volt, d-c motor, operated under adjustable control. This mill operates at speeds of 215 to 600 fpm, depending on the product size.

Following the hot saw, pipe passes over a 50 ft × 30 ft hot bed, through descaling rolls, and over a 54-ft hot bed to either of two run-out lines. These lines lead to straighteners and skids containing facing machines and hydraulic testing units.

There is also an electric weld tube mill, designed to produce light-wall conduit ½ to 2 in. in diameter. The mill consists of a seven-stand forming mill, an a-c welder, and a three-stand sizing mill. It operates at a maximum speed of 150 fpm. Coils from the tandem cold mill at the tin mill are slit to the desired width. At present, this unit is not operating.

Complete finishing facilities are installed for finishing standard or extra-heavy pipe or conduit in lengths of 18 to 42 ft, with plain, beveled or threaded ends, either black or galvanized.

Finishing facilities include this bake oven department for conduit in lengths of 18-42 ft.



MERCHANT MILLS

Two merchant mills provide facilities for the usual products of such mills. At present, structural shapes are not produced, the output being rounds, squares, hexagons, flats and some special bar shapes.

The larger mill is a 14-18 in. unit of 12 stands, in a cross country layout of five mill lines, producing about 20,000 tons per month. Steel comes from the 46-in. bloomer in sizes ranging from 3⅛ in. squares to 8 in. × 10-in. blooms, in lengths of 8 ft 6 in. to 14 ft 6 in., and is unloaded in an adjacent billet yard where it may be scarfed or mechanically chipped as needed.

The steel is heated in two 17 ft × 58-ft continuous heating furnaces, side charge, side discharge. They are fired, top and bottom, with gas or, as standby, with

TABLE VII

Merchant Mill Data

	Roll size, in.		Distance from preceding stand, ft-in.	Roll rpm
	Diameter	Body length		
14 - 18-in. mill				
No. 1 rougher	24¼	52½	—	11.29/33.88
No. 2 rougher	24½	52½	37-0	15.53/46.89
No. 3 rougher	22⅛	52½	52-0	23.13/69.40
No. 4 rougher	22⅛	52½	12-0	31.50/94.50
No. 5 rougher	22⅜	42	100-0	35.07/105.20
No. 6A intermediate	19	40½	122-0	38.96/116.88
No. 7A intermediate	19	40½	119-0	49.28/147.76
No. 6 intermediate	19¼	40½	—	51.43/154.29
No. 7 finisher	15	28	149-0	77.87/233.62
No. 8 finisher	15	28	—	87.27/261.82
No. 9 finisher	15	28	—	100/300
No. 10 finisher	15	28	—	100/300
10-in. mill				
No. 0 rougher	13.375	31½	—	8.312/39.481
No. 1 rougher	13.5	31½	6-2	11.733/55.73
No. 2 rougher	13.75	31½	6-0	18.63/88.49
No. 3 rougher	14.5	31½	6-0	26.471/125.73
No. 4 rougher	14.375	31½	6-0	39.286/186.6
No. 5 intermediate	12.81	24	30-0	40.91/102.27
No. 6 intermediate	12.625	24	4-6	60.23/150.58
No. 7 intermediate	13.0	24	18-0	82.375/205.92
No. 8 intermediate	12.87	24	4-6	117.5/293.75
No. 9 intermediate	10.5	20	—	173/432
No. 10 intermediate	10.5	20	—	212/495
No. 11 intermediate	10.08	20	—	258/580
No. 12 finisher	10.46	20	—	247.36/561.53
No. 13 finisher	10.56	20	3-9	352.49/800.17
No. 14 finisher	10.81	20	2-9	404.14/917.42
No. 15 finisher	10.87	20	2-9	449.75/1021.0
No. 16 finisher	11.125	20	2-9	498.78/1132.26

oil. Gas pressure, fuel-air ratio and furnace pressure are automatically controlled.

Table VII gives some details of the 14-18 in. mill. The first ten stands of this mill may be driven through gearing by a 5600-hp, 60 to 180 rpm, 600-volt, d-c shunt motor. If desired, stand No. 1 may be used as a reversing rougher, individually driven by a 900-hp, 50 to 300 rpm, 600-volt, d-c motor, in which case the stand operates with roll speeds ranging 28.24 to 56.47 rpm. The last two mill stands are driven individually by two 1500-hp, 110 to 300-rpm, 600-volt d-c motors.

Steel may be rolled in a straight line through the first seven stands and delivered from stand No. 7A at speeds of 245 to 735 fpm to a 60-in. hot saw and on to a cooling bed 127 ft 6 in. long × 68 ft wide. In the runout table following this cooling bed is a roller straightener and a bar shear.

Sizes finished from No. 7A stand range 4 to 6-in. diameter rounds, 3¾ to 6 in. squares, and flats from 8 in. × ¾ in. to 13 in. × 1 in.

Smaller sizes are produced by taking steel from No. 5 stand and passing it on through all or some of stands No. 6, 7, 8, 9 and 10. Transfers are installed between the first and second mill lines on both sides of No. 5 and No. 6 stands, and another joins the fourth and fifth lines, while diagonal tables connect the second, third and fourth lines. This layout provides a very flexible arrangement.

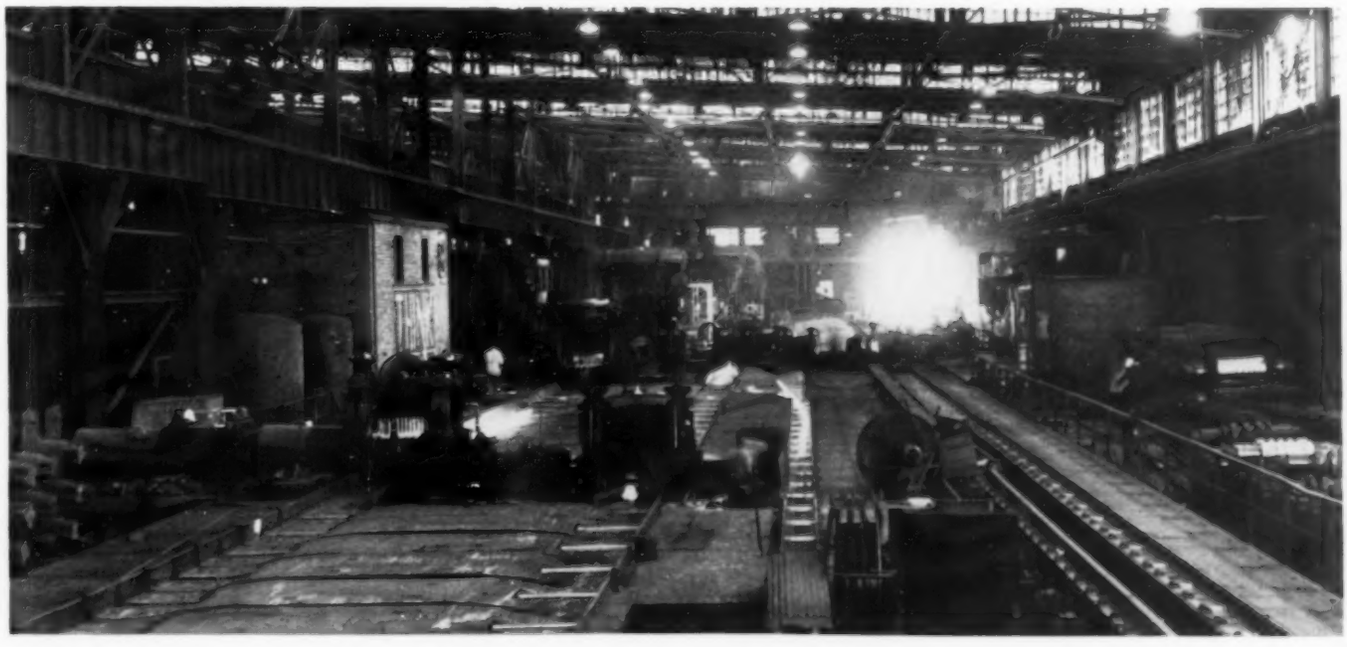
Sizes finished out of No. 10 stand run 1 1/16 to 3 5/16 in. diameter rounds, 1 7/16 to 3½ in. squares, 1 5/16 to 2 3/16 in. hexagons, and flats 2 to 6 in. wide and ¼ to 2 in. thick.

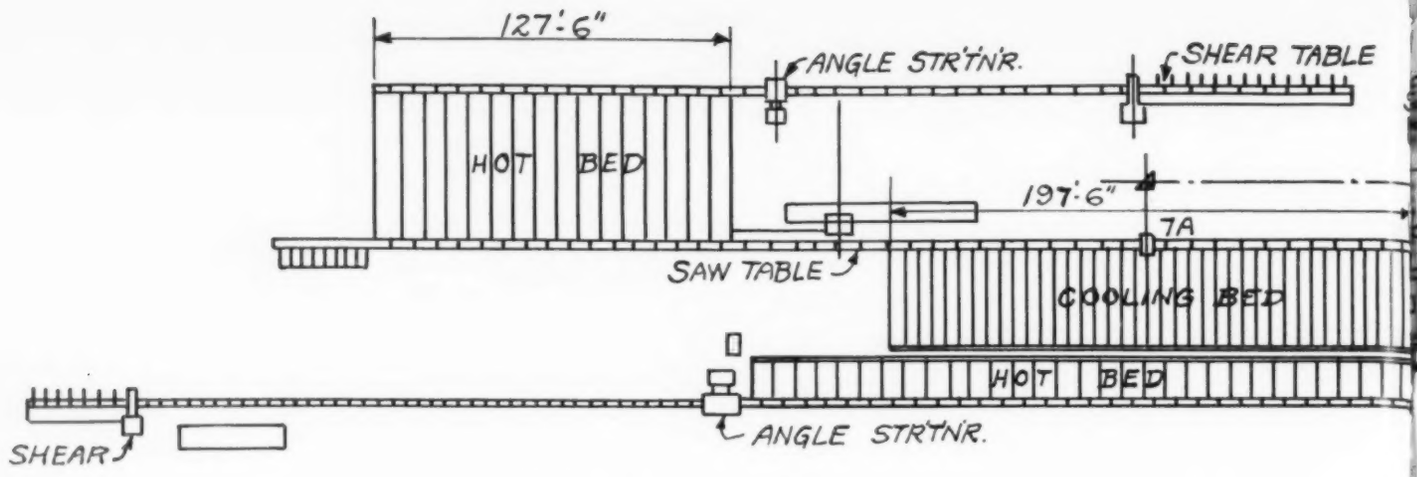
Steel leaves No. 10 stands at speeds up to 1100 fpm, and passes either to a cooling bed 270 ft long × 13 ft 8 in. wide on one side of the mill runout or a 200 ft × 13-ft bed on the other side. From the former bed, the product passes on to a straightener and a shear. From the latter bed, product passes to the runout table from No. 7A stand and on to the hot bed serving that line.

In the area beyond the cooling beds are various finishing facilities, including slow cooling pits, gag presses, roller straighteners, turning, sizing and polishing machines, cold saw, pickling facilities and four 8 ft × 30-ft car type annealing furnaces.

The smaller sizes of merchant mill products are made on the 10-in. mill, which rolls about 10,000 tons per month, approximately 25 per cent alloy steels, 75 per

The 14-18 in. merchant mill, a cross-country unit, rolls about 20,000 tons per month in a wide range of sizes of rounds, squares, hexagons and flats.





Plan of 14-18 in. merchant mill.

cent carbon steel. Billets ranging 1¾ in. to 2¾ in. square are reduced to ⅜ to 1-in. diameter rounds, ½ to 13/16-in. squares, 9/16 to 13/16-in. hexagons, flats from 1 in. × 3/16 in. to 2½ in. × ⅜ in., and rods down to No. 5.

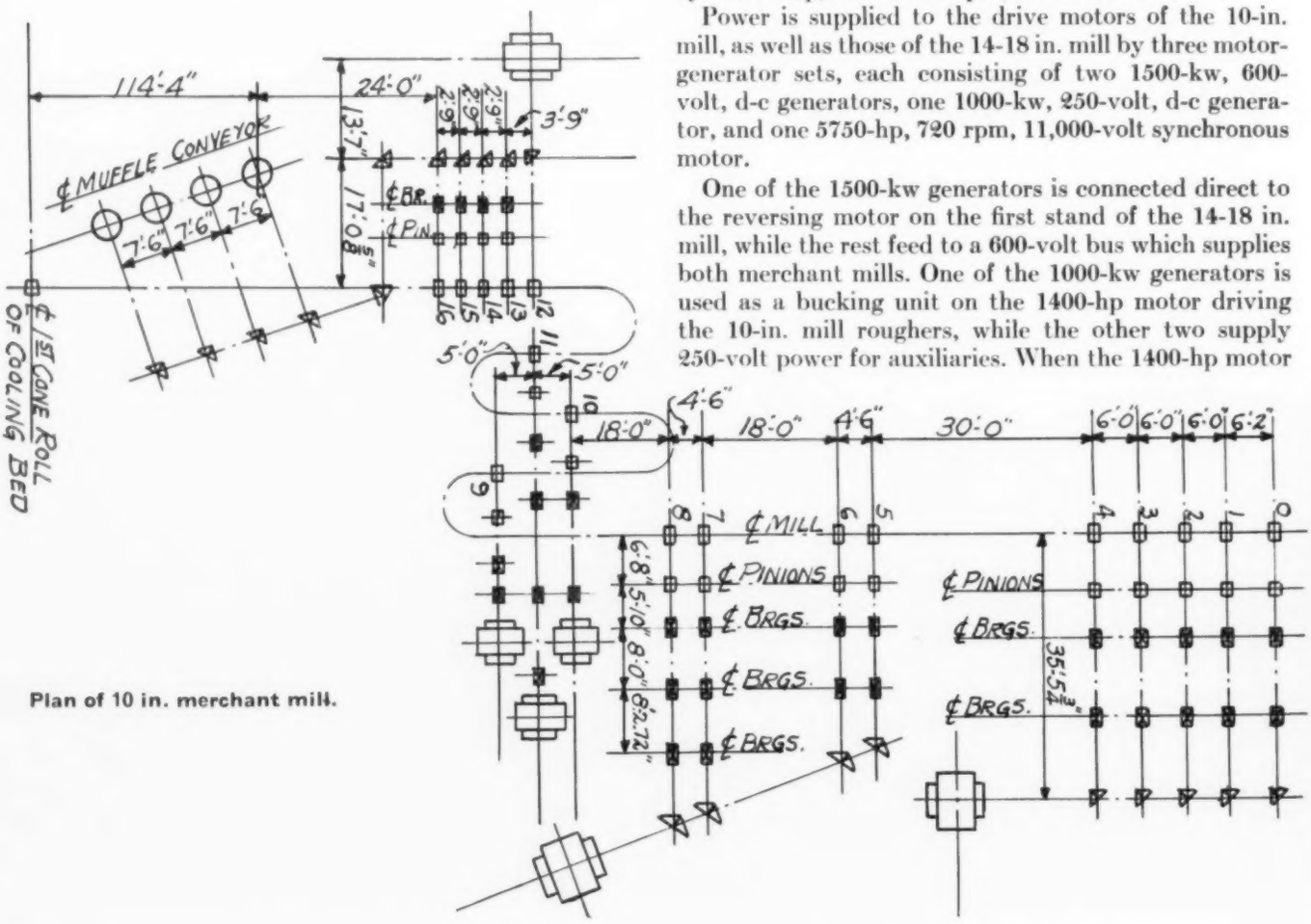
Billets are heated in a 30 ft × 30 ft top-fired continuous furnace, side-charge, side-discharge. It is fired with gas or oil.

The 10-in. mill consists of five continuous roughing stands, seven intermediate stands (four in line, three looping), and five stands of continuous finishers, all equipped with composition bearings. Loopers are installed between No. 8 and No. 9 stands, between No. 9 stand and No. 10 stand, between No. 10 and No. 11 stands, and between No. 11 and No. 12 stands, but automatic looping is done only between No. 8 and 9 stands and between No. 10 and 11. A flying shear is located between seventh and eighth stands of the mill.

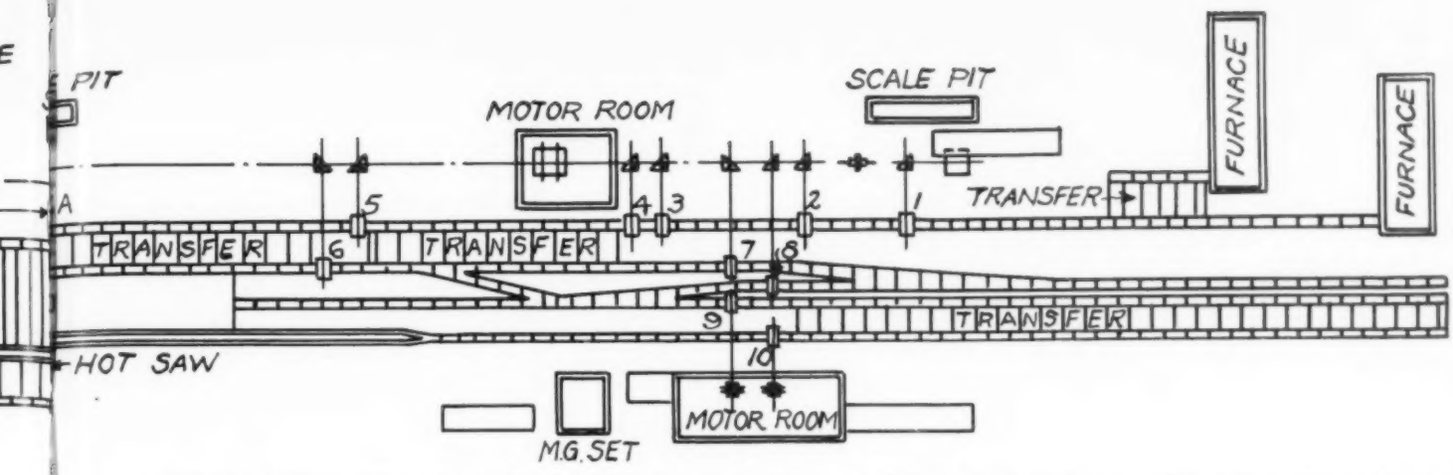
The five roughing stands are driven through line shaft and bevel gears by a 1400-hp, 63.3 to 190 rpm, 600-volt, d-c motor. The next four stands have a 1500-hp, 135 to 337.5 rpm, 600-volt, d-c drive motor, also connected by line shaft and bevel gearing. The three looping stands are individually driven by 500-hp, 600-volt, d-c motors, of 173 to 432 rpm, 212 to 495 rpm and 258 to 580 rpm, respectively. The continuous finishing train is driven through a line shaft and bevel gears by a 1500-hp, 300 to 681 rpm, 600-volt, d-c motor.

Power is supplied to the drive motors of the 10-in. mill, as well as those of the 14-18 in. mill by three motor-generator sets, each consisting of two 1500-kw, 600-volt, d-c generators, one 1000-kw, 250-volt, d-c generator, and one 5750-hp, 720 rpm, 11,000-volt synchronous motor.

One of the 1500-kw generators is connected direct to the reversing motor on the first stand of the 14-18 in. mill, while the rest feed to a 600-volt bus which supplies both merchant mills. One of the 1000-kw generators is used as a bucking unit on the 1400-hp motor driving the 10-in. mill roughers, while the other two supply 250-volt power for auxiliaries. When the 1400-hp motor



Plan of 10 in. merchant mill.



operates above base speed, the bucking generator feeds into the general bus.

Mill speeds, etc., for the 10-in. mill are given in Table VII.

Steel may be delivered at speeds of 825 to 1875 fpm from No. 12 stand on to a cooling bed 450 ft long × 7 ft 1½ in. wide, or, if small enough, to four pouring reels. Small rod is finished out of No. 16 stand at speeds up to 3300 fpm and goes directly to the coilers. Larger rod may be finished out of No. 14 stand at speeds up to 2590 fpm. From the reels, a conveyor takes coils through a cooling muffle to a hook carrier.

Coiled rod may be annealed in three gas-fired bell-type furnaces. Facilities for pickling and liming rod are also available. Also in the west end of the 10-in. mill building is a spike department containing two heating furnaces and two spike machines. This department has a rated capacity of 1200 tons of track spikes per month.

HOT STRIP MILL

An important unit in the development of the Indiana Harbor plant is the 54-in. continuous strip mill, which was started up in 1939. This mill has a nominal capacity of 1,680,000 tons per year and rolls material up to 51 in. in width, with thicknesses ranging from ⅜ in. to No. 18 gage. About 30 per cent goes into hot finished product, 40 per cent into cold finished sheet, and 30 per cent into tinplate.

Slabs, transported on railroad cars from the 45-in. blooming mill, range 20 to 52 in. in width, 4 to 7 in. thick, 76 to 186 in. long, and 3500 to 18,000 lb in weight. They are unloaded in the slab yard, where they are scheduled for rolling or stored, as desired. Cranes then move the slabs to hydraulically operated magazine feeders, from where they are moved into the furnaces by double pushers.

Four continuous slab heating furnaces are installed, two rated at 70 tons per hr and two at 67 tons per hr. The larger furnaces are 89 ft 4 in. long × 18 ft wide, the smaller 86 ft 10½ in. × 18 ft.

The furnaces are of the conventional triple-zone design, with six burners in each of the main top zone, bottom zone and soaking zone. They are usually fired with fuel oil, and have automatic controls on fuel-air ratio, temperature and furnace pressure. Air for combustion is heated in metallic tubular recuperators on the two newer furnaces, silicon carbide recuperators on the older furnaces.

The hot mill is a 10-stand unit with two scale breakers, following the conventional layout. General details of mill are shown in Table VIII. Because slabs are available in widths up to the maximum rolled on the strip mill, no broadside rolling is done. Hence, no turntables, pusher or squeezer are installed.

Integral vertical edgers are installed on the three 4-high roughing stands, with 20-in. diameter rolls driven

Slabs up to 52 in. wide, 4-7 in. thick, are broken down in the roughing stands of the 54-in. hot strip mill.

Strip 0.0478⅜ in. thick is rolled in the hot strip finishing train with delivery speeds up to 2059 fpm.

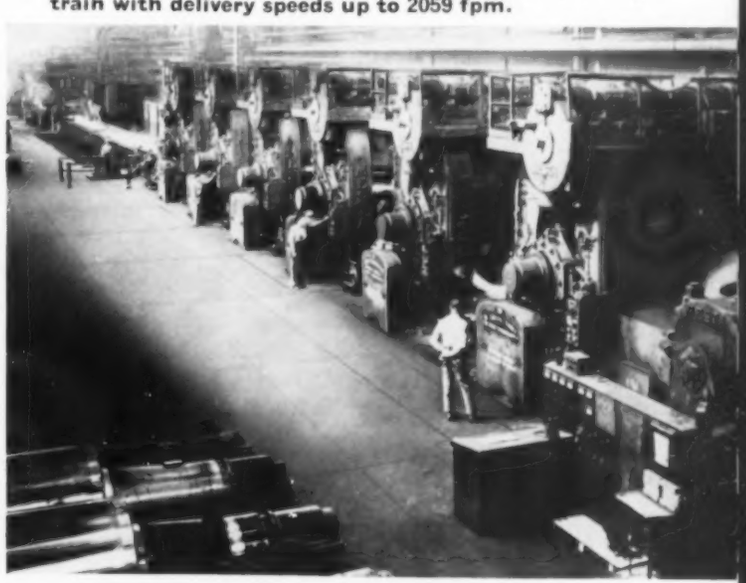


TABLE VIII

Strip Mill Data

Stand	Work roll		Back-up roll		Distance from preceding stand, ft-in.	Motor data				Gear ratio	Roll rpm	Roll face speed, fpm
	Diameter, in.	Body length, in.	Diameter, in.	Body length, in.		Hp	Volts	Type	Rpm			
Hot Strip Mill												
Vertical scalebreaker	40	8¼	—	—	—	300	2300	Ind	508	28.57	17.78	186
No. 1 rougher	40	56	—	—	27-10	3000	2300	Synch	144	7.8	18.46	193
No. 2 rougher	24½	54	45	54	39-9	2500	2300	Ind	234	5.1	45.78	294
No. 3 rougher	22½	54	45	54	55-6	2500	2300	Ind	252	4.23	59.46	350
No. 4 rougher	22½	54	45	54	82-6	2500	2300	Ind	252	4.23	59.46	350
No. 2 scalebreaker	25½	56	—	—	122-3	500	600	d-c	150/600	8.81	17.0/68.1	114/455
No. 5 finisher	22½	54	45	54	14-8	3000	600	d-c	200/400	5.11	39.1/78.2	231/461
No. 6 finisher	22½	54	45	54	18-0	3000	600	d-c	200/400	2.9	68.8/137.6	405/810
No. 7 finisher	22½	54	45	54	18-0	3000	600	d-c	200/400	1.976	101.2/202.4	596/1192
No. 8 finisher	22½	54	45	54	18-0	3000	600	d-c	200/400	1.551	129. /257.9	760/1519
No. 9 finisher	22½	54	45	54	18-0	3000	600	d-c	200/400	1.315	152.1/304.2	896/1791
No. 10 finisher	22½	54	45	54	18-0	(2)2250	600	d-c	230/460	1.316	174.8/349.6	1030/2059
Skin pass (coils)	28	54	—	—	—	200	230	d-c	500/1000	10.6	47.2/94.4	367/734
Skin pass (sheet)	28	60	—	—	—	250	440	a-c	1180	40.324	29.3	215

by a 150-hp, 460 to 1150-rpm, 230-volt, d-c motor on each stand.

Preceding the finishing train is a rotary crop shear driven by a 75-hp, 515 to 1030-rpm, 230-volt, d-c motor.

Loopers, actuated by 200 lb-ft torque motors, are installed between the finishing stands to control any slack occurring in the strip between stands. An idler roll on each looper takes the place of any table roll between these stands.

Hot mill screwdown mechanisms are driven by 230 volt d-c motors, with two 50-hp motors on the vertical edger, one 35-hp motor on the first rougher, and two 35-hp motors on all four-high stands. Edger rolls and those in No. 2 scalebreaker are adjusted by a 15-hp motor on each stand. Where two motors are used, magnetic clutches are installed so that the screws in a stand may be operated individually or in unison.

Roller bearings are used for the vertical scalebreaker roll necks and for the work roll necks of all four-high stands. Oil film bearings are used on the roll necks of the two-high rougher, the finishing scalebreaker, and the back-up rolls of the four-high mills. Rolls are hydraulically balanced.

Hot mill lubrication is effectively performed by automatic oil and grease systems, located in a series of oil cellars under the hot mill floor, and in a grease pump house and an oil filter house conveniently located on the hot mill floor.

To insure a high quality of strip surface, hydraulic descaling sprays are provided at the first three roughing stands. The sprays are controlled by solenoid-actuated, air-operated valves, and water is supplied by two 1000-gpm, 1100-psi, centrifugal pumps, each driven by a 1000-hp, 2300-volt motor.

Strip temperature is watched carefully along the mill, with radiation pyrometers at the exit side of stand No. 1, on the holding table between roughing and finishing trains, between No. 9 and No. 10 finishers.

A rotary flying shear is installed at a distance of 11 ft 9 in. after the last finishing stand. It is designed for cutting lengths from 14 ft to 56 ft, and is driven by two 150-hp, 230-volt, d-c motors.

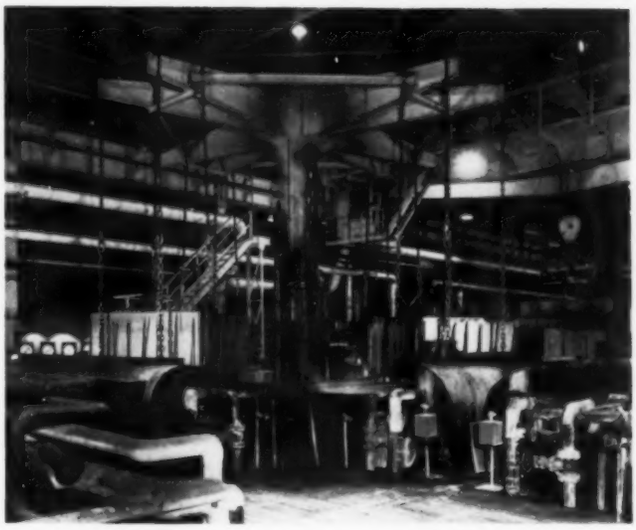
From the flying shear, the runout table extends about 425 ft to the coilers. This table is divided into four control sections, totaling 134 rollers each driven by an individual 4-hp, 750-rpm, 230-volt, d-c motor under adjustable voltage control. A maximum table speed of 2035 fpm is attained.

There are three down-coilers, which form coils of 25 in. inside diameter, 48 in. maximum outside diameter. Two of these form coils through the action of cluster rolls around the periphery, driven by eight 15-hp, 1200-rpm, 230-volt, d-c motors. The third coiler is of the rotating mandrel type and is driven by a 250-hp, 575 to 1437-rpm, 230-volt, d-c motor.

Coils may weigh up to 18,000 lb if of 48-in. width, but the average weight is around 9300 lb.

Between the slab yard and the hot mill building is the hot mill motor room, housing all main hot mill drives, reduction gear sets, control equipment, transformers and switchgear. Roughing mill drive motors use reactor and secondary resistance starting, while finishing train motors operate under adjustable voltage control. These d-c motors receive power from two motor-generator sets, each consisting of two 3000-kw, 600-volt, d-c generators and one 8400-hp, 360-rpm, 11,000-volt, synchronous motor.

The six finishing stands of the hot strip mill are each driven by a 3000-hp, 600 volt d-c motor.



Hot strip finishing facilities include two four-arm, vertical plunger, batch picklers for cut lengths.

Also housed here are the motor-generator sets which serve loopers, runout table and coilers, all of which operate on d-c power.

Electrical machinery is cooled by a closed recirculating system in which air is cooled in surface type coolers, and blown into the motor room, which is thus kept under slight pressure. Air passes down through the machines and back to the coolers. A total circulation of 385,000 cfm is afforded by ten fans, while two more fans provide a make-up capacity of 40,000 cfm.

Power comes to the motor room at 11,000 volts. Metalclad switchgear is used, and all 11,000 volts are rated at 1200-amp, 500,000-kva rupturing capacity. The entire hot mill is served from this station, and 11,000-volt circuits feed out to the cold mill and tin mill substations.

Hot finishing equipment is installed in a large building paralleling the hot mill building. Here are two four-arm vertical plunger picklers, with scrubbing, drying and oiling equipment. Sheet and plate up to 15 ft long × 50 in. wide may be processed here.

There are also two two-high skin pass mills (see Table VIII), one equipped to roll coiled material, the other for cut lengths. A four-high roller leveler follows the latter mill.

There is also two 51-in. coil processing, trimming and shearing lines, as well as a shearing line for plate up to ⅜ in. thick, miscellaneous resquaring shears for sheet and plate, roller levelers, etc.

A roll shop located adjacent to the hot mill contains a 50-in. roll lathe, a 34-in. roll lathe, two 50-in. × 192-in. roll grinders and a 30 in. × 192-in. grinder.

TINPLATE DEPARTMENT

Coils from the hot strip mill that are to be cold finished may follow either of two paths, depending on whether they are to be finished as tinplate or as cold rolled sheet.

For tinplate, coils are first moved by conveyors to two continuous pickling lines located adjacent to the coil storage building. One line can take material up to 38 in. wide, the other up to 51 in. wide. Both lines are approximately 550 ft long overall, and contain the usual uncoiler, crop shear, flash welder, trimmer, stitcher, pinch rolls and looping pit.

Each line contains seven tanks, the five pickling tanks running 45 to 60 ft long and the two rinse tanks 26 ft long. The acid tanks are of steel construction, lined with rubber and brick and with rubber lined covers. Tanks are connected to a common vent system from which a fan removes fumes to the outside through rubber-lined ducts.

Acid solutions are heated by steam, the temperatures being automatically maintained at about 200 F. The cascade system is used, with acid solutions from each tank as the solution becomes inactive. Solutions range up to 15 per cent sulphuric acid. The first tank is dumped when its strength drops to about 7 per cent acid.

Emerging from the acid tanks, strip passes through a cold water rinse and a hot water rinse, followed by a dryer, a shear and a coiler.

Both lines operate at speeds up to 300 fpm, with the entry and exit ends capable of higher speeds to make up for delays in joining and cutting apart successive coils. The 38 in. line handles coils up to 12,000 lb in weight, while the 51-in. line handles coils up to 30,000 lb.

From the exit ends of the picklers, coils, ready for cold rolling, are conveyed across the end of the raw coil storage to the pickled coil storage, from where they are taken to the cold mills.

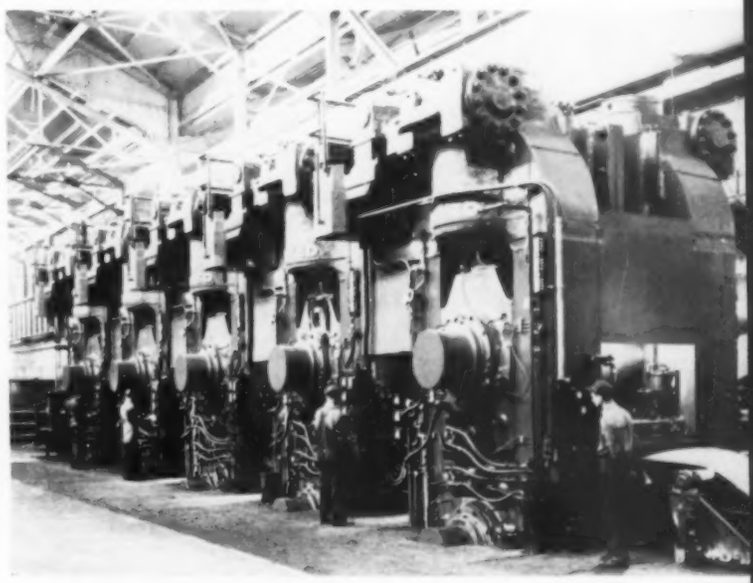
Cold reduction facilities in the tin mill consist of a five-stand, 48-in. tandem mill and a single stand 42-in. reversing mill. Some details of these units are given in Table IX.

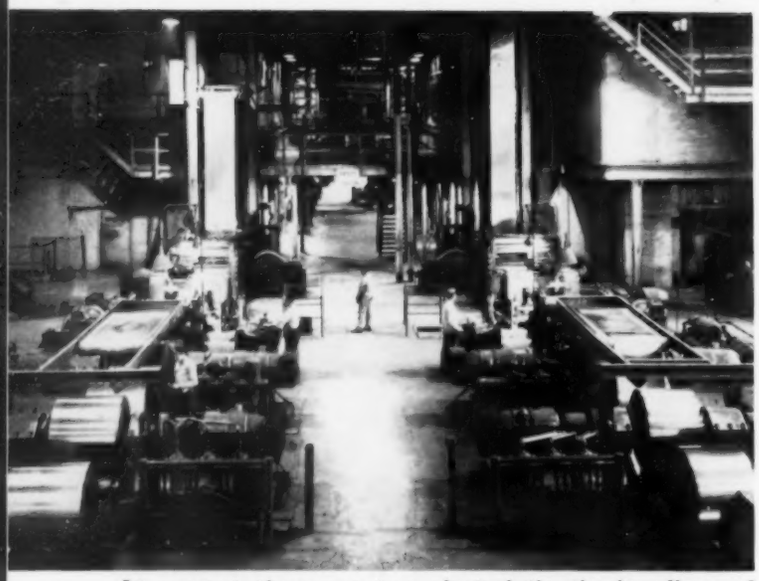
The tandem mill takes strip 18 to 36 in. wide and 0.062 to 0.085 in. thick, and produces gages 0.0077 to 0.048 in., averaging 325 tons per 8-hr turn.

Mill screws on each stand are driven by two 35-hp, 230-volt, d-c motors. The reel, 20 in. in diameter, is driven by a 400-hp, 600-volt, d-c motor.

The five mill drive motors and the reel motor operate under adjustable voltage control, receiving power from a motor-generator consisting of two 2500-kw, 600-volt, d-c generators, one 350-kw generator for the reel, a

This five-stand 48-in. tandem cold reduction mill reduces strip 18-36 in. wide from 0.062-0.085 in. in thickness down to 0.0077-0.048 in. in thickness.





At present there are two electrolytic tinning lines of alkaline type producing about 21,000 tons per month of tinplate with coatings up to 0.75 lb per base box.

125-kw exciter, and a 9000-hp, 11,000-volt, 514-rpm synchronous motor.

The reversing mill also rolls strip 18 to 36 in. wide, producing 0.0088 to 0.048 in. gages at an average rate of about 50 tons per 8-hr turn. Two 500-hp motors drive the reels for this unit. A 2250-kw motor-generator set serves main and reel drive motors.

Both of these cold mills have roller bearings on the work roll necks and oil film bearings on the back-up necks. Lubrication of both mills is effected by automatic oil and grease systems. Automatic gagers and strip tension indicators are provided on both mills.

Three roll grinders (one 24 in. × 144 in., one 53 in. × 244 in., and one 24 in. × 120 in.) keep rolls in shape for the cold mills in this department.

After cold reduction, strip intended for tinplate is electrolytically cleaned to remove all oil remaining on it from the rolling process. Three caustic cleaning lines of conventional design are installed, taking strip 18 to 36 in. wide and 0.0077 to 0.024 in. thick and operating at speeds up to 1100 fpm. In each line there is the usual uncoiler, lap welder, washer, electrolytic cleaning tank, rinse tank, dryer, pinch rolls and winding reel.

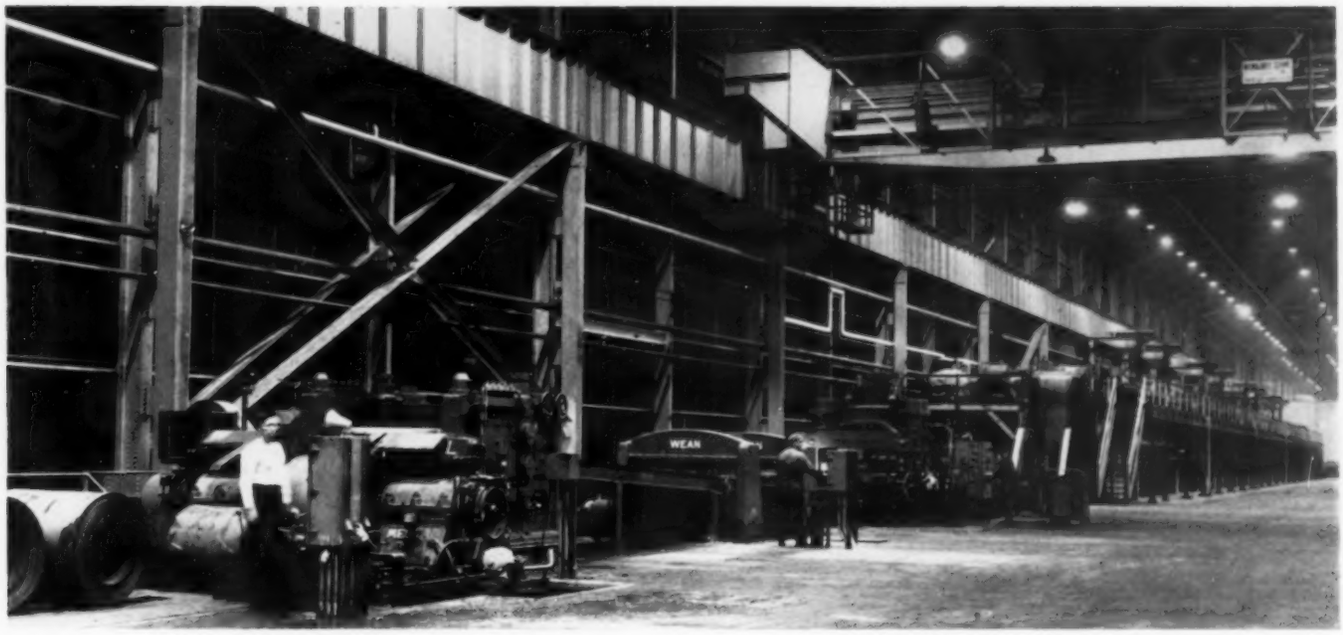
To soften the strip and relieve the strains of cold reduction, it is next annealed. This is performed in batteries of gas-fired, car type, in-and-out annealing furnaces. There are 12 double chamber furnaces, each chamber 21 ft 6 in. long × 8 ft 6 in. wide, taking a charge of about 40 tons with coils piled three-high. There are also three four-chamber furnaces. These chambers are 27 ft 6 in. × 13 ft 6 in. and take an 80-ton charge of coils or cut lengths.

Specially prepared atmosphere protects the steel from sealing during the annealing process, which is carried on at automatically controlled temperatures of 1150-1300 F. Annealing capacity here is about 35,000 tons per month. The furnaces are served by floor type chargers.

The annealed strip is next flattened and tempered to the desired degree by rolling in the temper mills, where a very slight reduction is made. Two two-stand, 42-in. mills are installed for this purpose, giving a total pro-

TABLE IX
Cold Mill Data

Stand	Work roll		Back-up roll		Distance from preceding stand, ft-in.	Motor data				Gear ratio	Roll rpm	Roll face speed, fpm
	Diameter, in.	Body length, in.	Diameter, in.	Body length, in.		Hp	Volts	Type	Rpm			
Tin mill department												
Tandem mill												
No. 1	20	48	49	48	—	1500	600	d-c	300/600	5.87	51/102	267/534
No. 2	20	48	49	48	13-0	1750	600	d-c	300/600	3.94	76/152	398/796
No. 3	20	48	49	48	13-0	1750	600	d-c	300/600	2.63	114/228	597/1194
No. 4	20	48	49	48	13-0	1750	600	d-c	300/600	1.9	158/316	826/1652
No. 5	20	48	49	48	13-0	1750	600	d-c	175/437	Direct	175/437	915/2288
Reversing mill	16½	42	49	42	—	1750	600	d-c	400/600	2.15	186/279	804/1205
Two-stand	18	42	49	42	—	350	230	d-c	215/430	Direct	215/430	1015/2030
temper mill	18	42	49	42	13-6	350	230	d-c	215/430	Direct	215/430	1015/2030
Two-stand	18	42	49	42	—	600	600	d-c	427/637	Direct	427/637	2020/3010
temper mill	18	42	49	42	13-6	600	600	d-c	427/637	Direct	427/637	2020/3010
Cold reduced sheet department												
Tandem mill												
No. 1	21	56	56	56	—	3000	600	d-c	90/260	Direct	90/260	495/1430
No. 2	21	56	56	56	13-0	(2)2500	600	d-c	136/340	Direct	136/340	748/1870
No. 3	21	56	56	56	13-0	(2)2500	600	d-c	212/477	Direct	212/477	1166/2624
No. 4	21	56	56	56	13-0	(3)1750	600	d-c	255/637	Direct	255/637	1403/3504
Temper mill	21½	56	56	56	—	(2) 500	500	d-c	500/1000	1.676	298/596	1680/3360
Temper mill	22½	56	56	56	—	(2) 500	500	d-c	500/1000	1.676	298/596	1757/3514



At the cold reduced sheet department, hot rolled coils are first put through this 60-in. continuous pickling line. It contains a single pickling tank 384 ft long.

duction of about 450 tons per 8-hour turn. Some details of these mills are given in Table IX.

The older mill receives power from a 1000-kw, 230-volt, d-c motor-generator set, the newer mill from a 1500-kw, 600-volt set.

After the temper rolling, the strip is ready for tinning, which may be done by either of two processes, according to the product desired. For the lighter coatings (up to 0.75 lb per base box), two electrolytic tinning lines are installed, giving a total capacity of about 21,000 tons per month.

Both of these lines use the alkaline plating process, with sodium stannate as electrolyte. One line operates with 90,000-amp current and tins at rates of 800 fpm for 0.25 lb coating, 500 fpm for 0.5 lb coating and 280 fpm for 0.75 lb coating. The other line, with 120,000 amp, runs at 800 fpm for 0.25 lb coating, 600 fpm for 0.5 lb coating, and 400 fpm for 0.75 lb coating.

Coiled material is brought to these lines by industrial trucks and, from the uncoiler, the strip passes through a shear, welder, side trimmer, looping tower, acid dip pickler, rinse tank, electrolytic cleaner, alkaline plating tanks, rinse tanks, ammonium chloride flux tank, induction heat reflow coils, water quench tank, electrochemical tank, chromic acid dip tank, branner and oiler, and is finally recoiled.

The tinned coils are then put through one of six shearing lines which operate at speeds of 450 to 800 fpm and handle 60 to 90 tons each per 8-hour turn.

For tin coatings heavier than 0.75 lb per base box, the temper-rolled strip is cut into 18 to 39 in. lengths, as desired, and then white-pickled in batch type picklers. Tinning is carried out in 16 hot-dip tinning stacks, nine of 75 in. width, seven of 66 in. width. Six of these stacks are equipped with assorting lines.

Three separate assorting lines are also available for use on material from either tinning process.

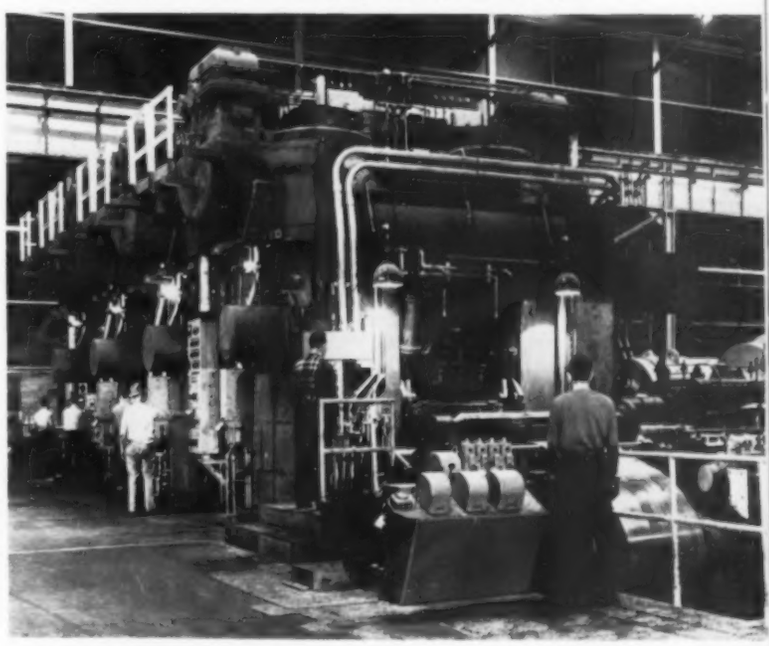
The tin mill has rated annual capacities for 228,000 tons of electrolytic tinplate, 168,000 tons of hot-dip tin and terne plate, and 48,000 tons of black plate.

COLD REDUCED SHEET DEPARTMENT

The cold reduced sheet mill, the most recent expansion to be completed, is designed to produce 50,000 tons of sheets per month. The 43-acre site for this plant, separated from the rest of the plant by a highway, is occupied by seven buildings covering an area of about 19 acres. Table X gives the sizes and crane facilities of these buildings.

Hot rolled coils from the 54-in. mill are brought to the sheet mill by railroad. A 60-in. continuous pickling line is installed here with a rated capacity of 600 tons per 8-hour turn. This unit is 767 ft long, and contains only four tanks, but one of these is 384 ft long × 7 ft

This four-stand 56-in. tandem mill is heavily motored and operates with delivery speeds up to 3500 fpm.



Cold reduced coils and cut lengths are annealed in portable cover type furnaces fired with coke oven gas.

3 in. wide × 4 ft 11⅜ in. deep, and holds 66,000 gal of pickling solution. The first tank is 44 ft long and holds 20,000 gal of water. Following this is the large tank, and then a 40-ft, 7800-gal cold water rinse tank and a 44-ft, 20,000-gal hot water rinse tank.

The long tank is baffled so that cascading of the solution can be carried on. The use of one long tank instead of several shorter ones gives more pickling in a given length and also reduces the quantity of rollers and attendant parts.

Otherwise conventional in design, this pickler is designed to handle strip 18 to 60 in. wide and 0.048 to 0.187 in. thick. The entry end can operate up to 1500 fpm, the delivery end up to 600 fpm.

Cold reduction facilities in the new plant consist of a four-stand, 56-in. tandem mill designed to handle coils up to 50,000 lb in weight, of 18 to 50 in. width, rolling at speeds up to 3500 fpm. It is rated at 1000 tons per 8-hour turn on sheet gages. Table IX gives some details of this unit.

Multiple drive motors on stands No. 2, No. 3 and No. 4 are used to reduce the inertia effect, giving faster acceleration and deceleration. The reel is driven by two 600-hp, 220 to 800-rpm motors.

All of these motors draw power from two motor-generator sets, one with a 2500-kw generator for No. 1 stand, two 2000-kw generators for No. 2 stand and a 1000-kw generator for the tension reel.

The other set carries four 2000-kw generators (two each for stands No. 3 and No. 4). All of these generators are 600-volt d-c. Each set also has a 75-kw, 230-volt exciter and is driven by an 11,200-hp, 11,000-volt, 514-rpm synchronous motor.

The tandem mill is equipped with roller bearings on work roll necks, oil film bearings on back-up necks.

Mill screws on each stand are driven by two 75-hp, 230-volt d-c motors.

This mill can take coils up to 50,000 lb in weight, 18 to 50 in. wide, 22 in. inside diameter and 36 to 76 in. outside diameter. The finished coils are 20 in. inside diameter and 36 to 76 in. outside diameter. The mill is constructed with provisions for future widening to 66 in. if desired.

Facilities for sheet annealing are of the portable cover type, and include 22 furnaces with 63 bases for coils and four furnaces with 12 bases for cut lengths. The coil furnaces accommodate four stacks each, with coils up to 72 in. diameter piled up to a height of 156 in. The sheet furnaces take cut lengths up to 60 in. × 172 in.

These annealing furnaces are rated at 5.5 tons per furnace-hour. They are fired with coke oven gas and consume about 1,120,000 Btu per ton annealed.

Coil transfer cars operate on a track running the length of the annealing building and circling around through the adjacent coil storage No. 2, facilitating handling into and out of the annealing department.

For temper rolling, two single stand, 56-in. mills are installed, each rated at 500 tons per 8-hour turn. Each mill is driven by two 500-hp motors, as shown in Table IX. The reel for each mill is driven by a 1000-hp motor.

Each mill is served by a motor-generator set with a 1250-kw generator, a 450-kw generator (both 500-volt d-c), and a 2000-hp, 11,000-volt, 720-rpm synchronous motor.

TABLE X

Tin Mill and Sheet Mill Building Data

Building	Length, ft-in.	Width, ft-in.	Cranes	
			No.	Capacity, tons
Hot strip and tin mill				
Slab yard	696-0	94-2	2	25
			1	35
Hot mill motor room	504-0	60-4	1	35/5
Hot strip mill	696-0	74-0	1	60
			1	25
Hot mill runout	480-0	83-3	2	25
Roll shop	180-0	75-2½	1	15
Hot strip finishing	1104-0	73-6½	2	15
			1	25
Normalizing building	672-0	35-0½	1	10
Shipping and pickling	744-0	107-8½	2	15
Continuous pickling	648-1¾	65-0	1	10
Hot coil storage	600-0	93-6½	3	15
			1	25
			1	25/15
Reversing cold mill	552-1¾	73-6½	1	50/10
			1	15/5
Skin pass mills	336-0	60-2	1	50/10
Box annealing	480-1¾	103-9	2	15/5
Machine shop	144-0	73-8	1	10
Black annealing	1008-0	73-8	1	25/5
Cold mill shearing	480-0	36-8½	1	15
White annealing	804-0	73-8	2	15/5
Tin house machine shop	120-0	73-6½	1	5
Tin house	552-0	35-0½	1	5
Assorting and boxing	840-0	83-6½	1	5
Warehouse	840-0	73-6½	2	5
Cold sheet mill				
Annealing	912-0	135-0	2	50/15
Coil storage No. 2	816-0	137-10	2	25
Mill and roll shop	864-0	105-0	1	50
			1	75
Coil storage No. 1	672-0	137-10	2	25
Pickling	912-0	100-0	2	20
Salvage and sheet finishing	768-0	100-0	2	20
Warehouse	960-0	137-10	3	20

One mill is designed to roll coils only, the other being set up to roll either coils or cut lengths. Otherwise, the two mills are essentially duplicates. Finished coils may be cut into lengths on two shearing lines, designed to cut strip 18 to 50 in. wide, 0.015 to 0.062 in. thick, into lengths of 36 to 180 in. The lines operate at speeds up to 1000 fpm, and are rated at 250 tons each per 8-hour turn. Each line has an oiler, two prime pilers and a reject piler.

There is also a 66-in. line for side trimming, splitting or recoiling, designed for strip 18 to 60 in. wide, 0.015 to 0.074 in. thick. Coils 20 or 24 in. inside diameter and up to 72 in. outside diameter may be handled. The line is rated at 200 tons per 8-hour turn, and runs at speeds up to 1000 fpm. An oiler is installed in this line.

Another line is provided for side trimming or multiple slitting. This unit handles 18 to 38 in. strip 0.015 to 0.074 in. thick, and can slit down to as little as 2-in. widths. It averages about 100 tons per turn and operates at speeds up to 500 fpm. Coils as large as 60 in. outside diameter, with inside diameters of 16, 20 or 24 in., can be accommodated.

The finishing department also includes various squaring shears, a roller leveler, stretcher leveler, etc.

The sheet mill is served by a roll shop containing a 60-in. automatic roll lathe and a 60-in. roll grinder.

UTILITIES AND SERVICES

Electric power for the plant is furnished at 60 cycles from the company's powerhouse and from ties with the utility company serving the district.

The main powerhouse contains two 5625-kva, 3600-rpm and two 12,500-kva, 1800-rpm turbo generators, with surface condensers, all generating at 2300 volts and operating on 200-psi steam. There are also two 12,500-kva, 3600-rpm, 11,000-volt turbo generators operating on 800-psi steam and exhausting at 200 psi into the 200-lb system.

Purchased power comes in over double lines to two outdoor substations. One station, near the merchant mills, has three banks of 33,000/11,000 volt transformers, two of 20,000 kva, one of 6000 kva. The other station, located at the cold reduced sheet mill, has two 20,000-kva banks.

Fed from these two substations and from the topping turbines at the proper house, 11,000-volt power is distributed around the plant by an underground loop system. Power at 2300 volts comes from the low pressure turbo generators over underground lines leading to the individual departments. Some 2300-volt power is also provided through step-down transformers from the 11,000-volt system.

The newer mills operate on 11,000-volt power, the older units on 2300-volt power. Similarly, 250-volt d-c power for auxiliaries is provided by rectifiers in the newer installations, by motor-generators in the older parts.

The Harbor plant electric load sets up a 30-min demand of 87,000 kw, and uses about 48,000,000 kwhr per month with full operations. About two-thirds of this is generated in the plant, the remainder purchased.

Steam is supplied to the high pressure turbines by five boilers. Two of these are rated at 875 psi, 810 F, 141,000 lb per hr and are fired with pulverized coal. Two other boilers, rated at 169,000 and 175,000 lb per hr, respectively, operate at 900 psi, 875 F and burn blast furnace gas or pulverized coal. Still another unit, rated at 900 psi, 760 F, 300,000 lb per hr, burns blast furnace gas, pulverized coal, oil or coke oven gas.

Steam from these boilers passes through the topping turbines and into the 200-psi system in quantities up to 650,000 lb per hr. A pressure reducing valve also connects the two systems. The low pressure system is also fed from three 800-hp and six 600-hp bent-tube boilers fired with blast furnace gas or oil and operating at 250 psi, 490 F. The low pressure system also receives steam from the 17 waste heat boilers previously mentioned in connection with No. 1 and No. 2 open hearth shops.

All of these boilers are fed from a continuous cold lime-soda-zeolite water treating plant, designed for 120,000 gphr, and a hot lime-soda plant of 50,000 gphr. Internal phosphate treatment completes the process.

At the coke plant, there are six bent-tube, 200-psi, 470-F boilers fired with coke breeze on chain grate stokers. This house supplies steam to the strip mill as well as to the coke plant. This system is also connected into the general low pressure system. Feed water treatment for this house is entirely internal.

At the cold reduced sheet mill, steam for pickling and general plant usage is generated in four oil-fired boilers rated at 250 psi, 366 F, 28,000 lb per hr.

Service water comes from three sources. The original pump house takes water from the canal and contains five motor-driven pumps, one of 19,000 gpm, two of 15,000 gpm, one of 10,000 gpm, and one of 7700 gpm capacity. Water from this station flows through a 48-in. header to the steel plant, and through a 36-in. line to the coke plant and the hot strip and tin mills

To improve the water system, an unusual step was taken several years ago in constructing an underground tunnel of about 200 sq ft cross-section, about 3400 ft long. This tunnel, 220 ft below plant yard level, runs from the edge of the lake to a spot near the power house. At each end is a vertical shaft 14 ft in diameter. Water from the lake flows throw this U-tube arrangement without any pumping operation. At the low-head pumphouse near the power house, seven pumps (one 19,000 gpm, four 7700 gpm and two 4200 gpm) which draw water from the tunnel for condensers, etc. The 19,000-gpm unit sends water to the coke plant through a 24-in. line.

As the plant has expanded, a new pump house was installed near the lake end of the underground flume. This station contains one 15,000-gpm pump, two 10,417-gpm pumps and one 7700-gpm pump, all motor-driven. Water from these units flows through a 72-in. header to the new open hearth and blooming mill, and into the original plant system.

Service water consumption ranges 130,000,000 to 180,000,000 gal per day.

Fuel oil for the entire plant is at present received by tank car, truck and barge, although steps are being taken to have all shipments by barge.

Cars and trucks are unloaded by gravity and pumped to a 2,000,000-gal storage tank. Oil from barges is pumped to two 3,200,000-gal tanks, then to the same 2,000,000-gal tank. Steam coils for heating are installed at the suction outlet of each storage tank. Steam pumps then move the oil from the 2,000,000-gal tank to smaller receiving tanks at both open hearth shops, both blooming mills and the merchant and skelp mills, and to a 1,000,000-gal tank at the coke plant. This last tank supplies the slab heating furnaces of the hot strip mill. These receiving tanks have floats which automatically control the incoming oil as needed.

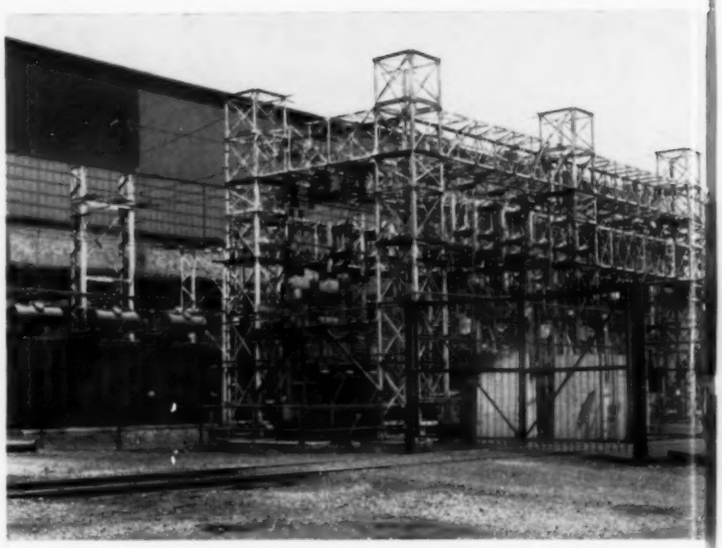
Each oil-consuming department is served by a recirculating loop system with a heater that raises oil temperature to 200 to 210 F. No. 1 open hearth, however, has an individual heater for each furnace.

Intra-plant shifting is done by diesel-electric locomotives operating on about 100 miles of standard gage tracks.

Maintenance work is carried on by a complete layout of shops covering the various crafts.

Close metallurgical control is maintained over all phases of production, from raw materials on to the finished products. Constant chemical and metallurgical testing, carried on in well equipped laboratories, insures quality and satisfaction of the customers' requirements. Research is constantly going on to improve products and processes.

The Chicago District now has about 10,600 employees. Apprentice training is given to many young employees, resulting in better jobs for the men and more skilled workers for the company. This work has been broadened by the addition of further technical training. An economic training course and a work simplification program are also carried on for foremen and supervisors.



This 46,000 kva, 33,000/11,000 volt outdoor substation is one of two points through which purchased power enters the plant.

EXPANSION

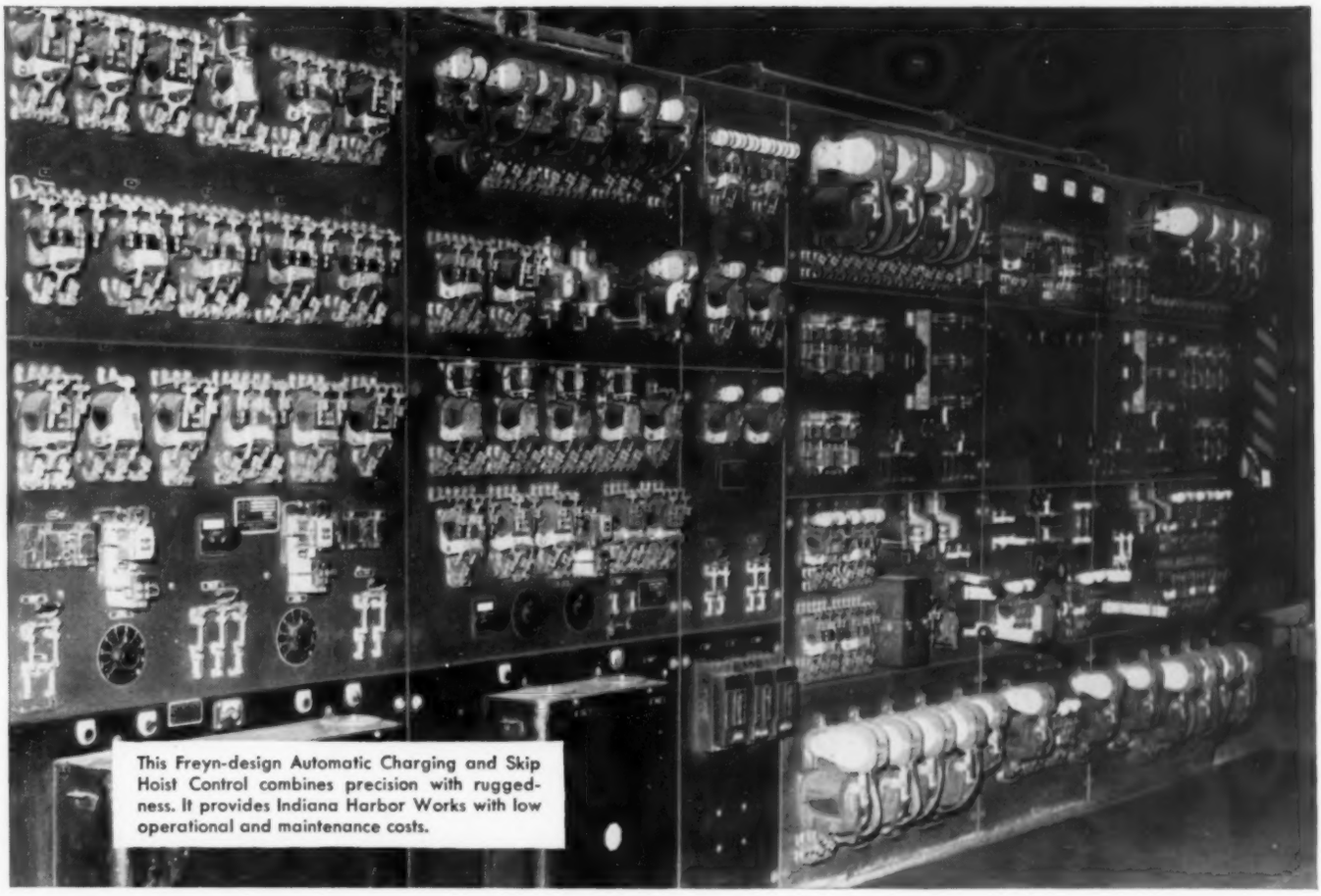
The Chicago District plants described in the foregoing have experienced constant growth, and the most recent program, started in 1950 and completed in early 1954, doubled the ingot capacity and materially broadened the product range. This program included new coke ovens, No. 3 blast furnace, No. 2 open hearth, No. 2 blooming mill, No. 2 butt weld pipe mill, an electric weld tube mill, and the cold reduced sheet mill, as well as many improvements and enlargements in the previously existing departments.

Now, on the heels of these major projects, further expansion has been announced. Two major expansion projects are at present under way. On an 88-acre tract just west of the recently completed cold reduced sheet mill, construction has begun on a new tin mill. Between the new slabbing mill and the lake front, work has begun on a new seamless tube mill.

The new tin mill will, at the start, consist of seven buildings housing cleaning lines, radiant-tube annealing furnaces, a high speed temper mill, electrolytic tinning line, shearing lines, and facilities for assorting and shipping. Steel for this department will be supplied from the cold reduced sheet mill.

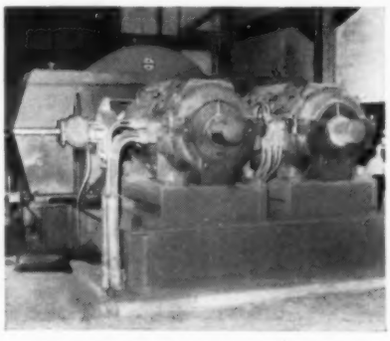
The new seamless tube mill will be designed to produce pipe from 4½ in. to 9⅝ in. outside diameter. Two principal buildings will house the mill and complete finishing and heat treating facilities.

Also under construction is a new battery of 75 coke ovens, with additional by-product and benzol equipment and improvements to the existing coal and coke handling facilities. This battery will coke 1800 tons of coal per day. An additional 25,000-kw turbo-generator and two high pressure boilers are also to be installed.

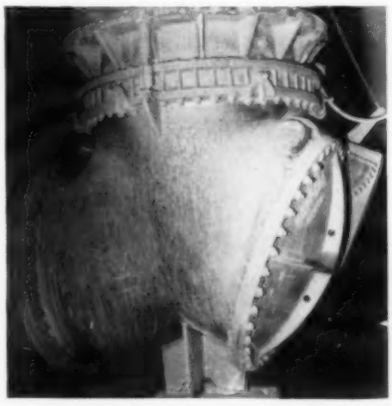


This Freyn-design Automatic Charging and Skip Hoist Control combines precision with ruggedness. It provides Indiana Harbor Works with low operational and maintenance costs.

Freyn-Design Combines Precision, Ruggedness in Automatic Blast Furnace Control



Freyn-design Skip Hoist (illustrated above), Chimney Valve (illustrated below), Bell Hoist and Stockline Recorder (not illustrated) make a compact, efficient, high production team.



At The Youngstown Sheet & Tube's
Indiana Harbor Works

Choosing the controls and equipment which would best handle the charging operation of their new No. 3 blast furnace at Indiana Harbor Works, East Chicago, Indiana presented no problem to The Youngstown Sheet and Tube Company—they chose Freyn-design controls and equipment. And here's why: First, because Freyn built-in precision offers safe, accurate operation. Second, because Freyn ruggedness gives years of dependable, trouble-free service. Third, because Freyn-design controls and equipment provide maximum production at lowest cost.

Proof of the ability of Freyn control equipment to provide precision and ruggedness plus efficient, low-cost operation is evidenced in Freyn installations in blast furnaces on every continent.

Freyn-design blast furnace equipment installed at Indiana Harbor Works adds to the already long—and continually growing—list of Freyn installations throughout the world. Freyn has—for over forty years—been the standard in blast furnace equipment. We invite you to consult with our engineers and management.

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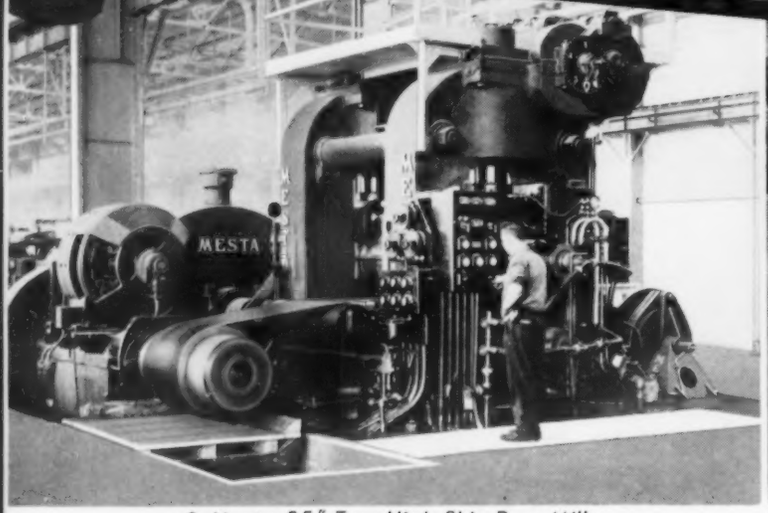
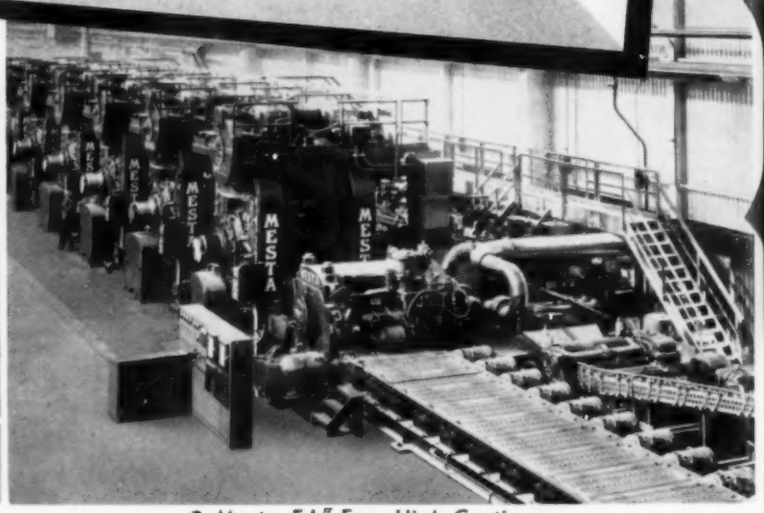
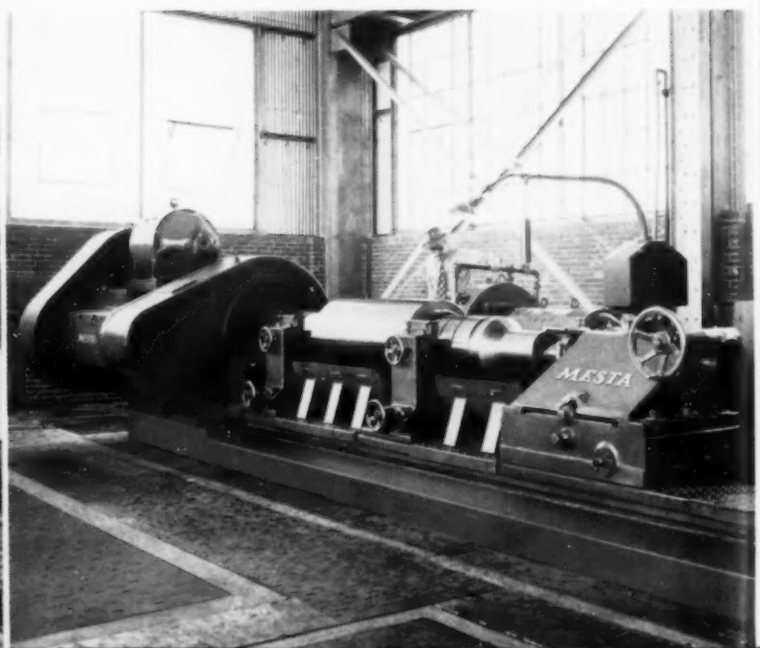


• Mesta 55″ Two-High Skin Pass Mill.



• Mesta 54″ Four-High Continuous Hot Strip Mill, Finishing Stands.

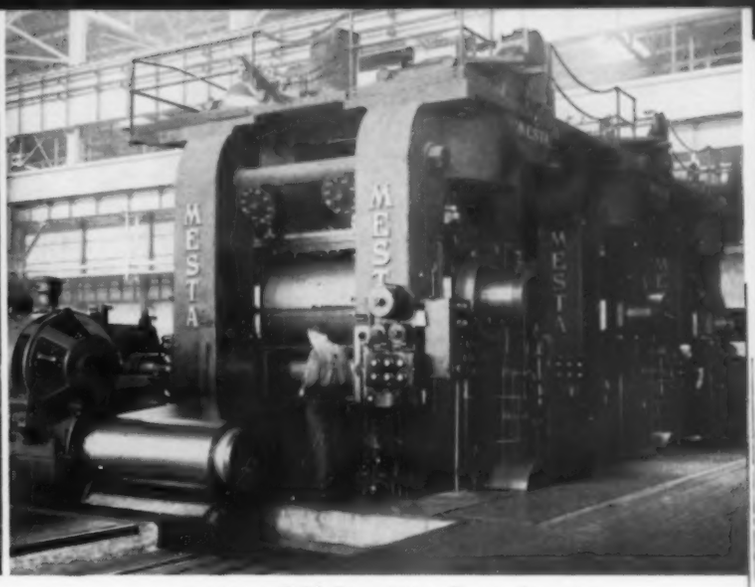
• Mesta 79″ Four-High Continuous Hot Strip Mill, Roughing Stands.



• Mesta Heavy Duty Traveling Wheel Type Roll Grinder.

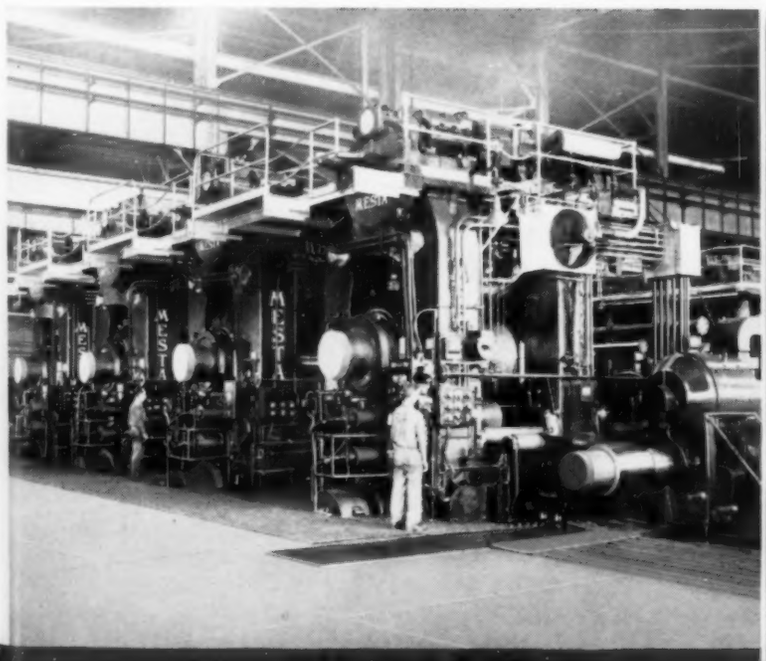
Designers and Builders of Complete Steel Plants

• Mesta 54" Four-High Continuous Hot Strip Mill, Roughing Stands.

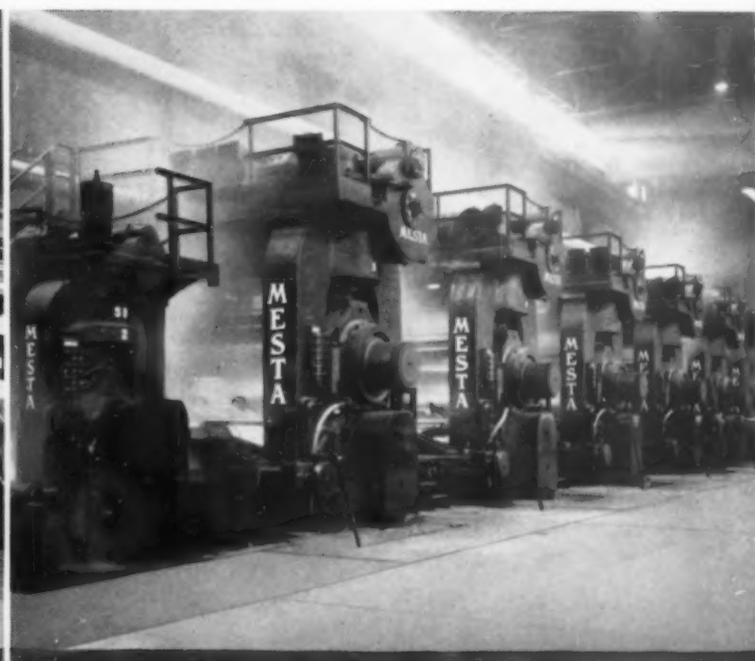


• Mesta 75" Four-High, Three-Stand Tandem Cold Mill.

Installed in the mills of...
YOUNGSTOWN SHEET and TUBE COMPANY



• Mesta 54" Four-High, Four-Stand Tandem Cold Mill.



• Mesta 75" Four-High Continuous Hot Strip Mill, Finishing Stands.

MESTA MACHINE COMPANY, Pittsburgh, Pa.

THE YOUNGSTOWN SHEET and TUBE COMPANY RELIES ON

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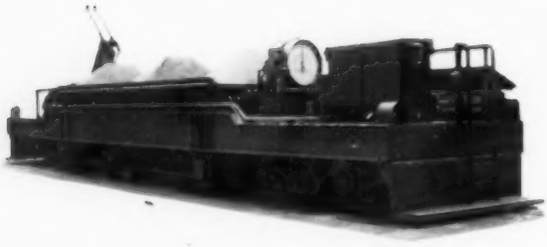
60-TON side dump ore transfer with 2-compartment hopper. Individually operated gates.



30-TON Electric Scale Charging Car Double hopper, bottom dump.

THE ATLAS CAR AND MANUFACTURING CO.

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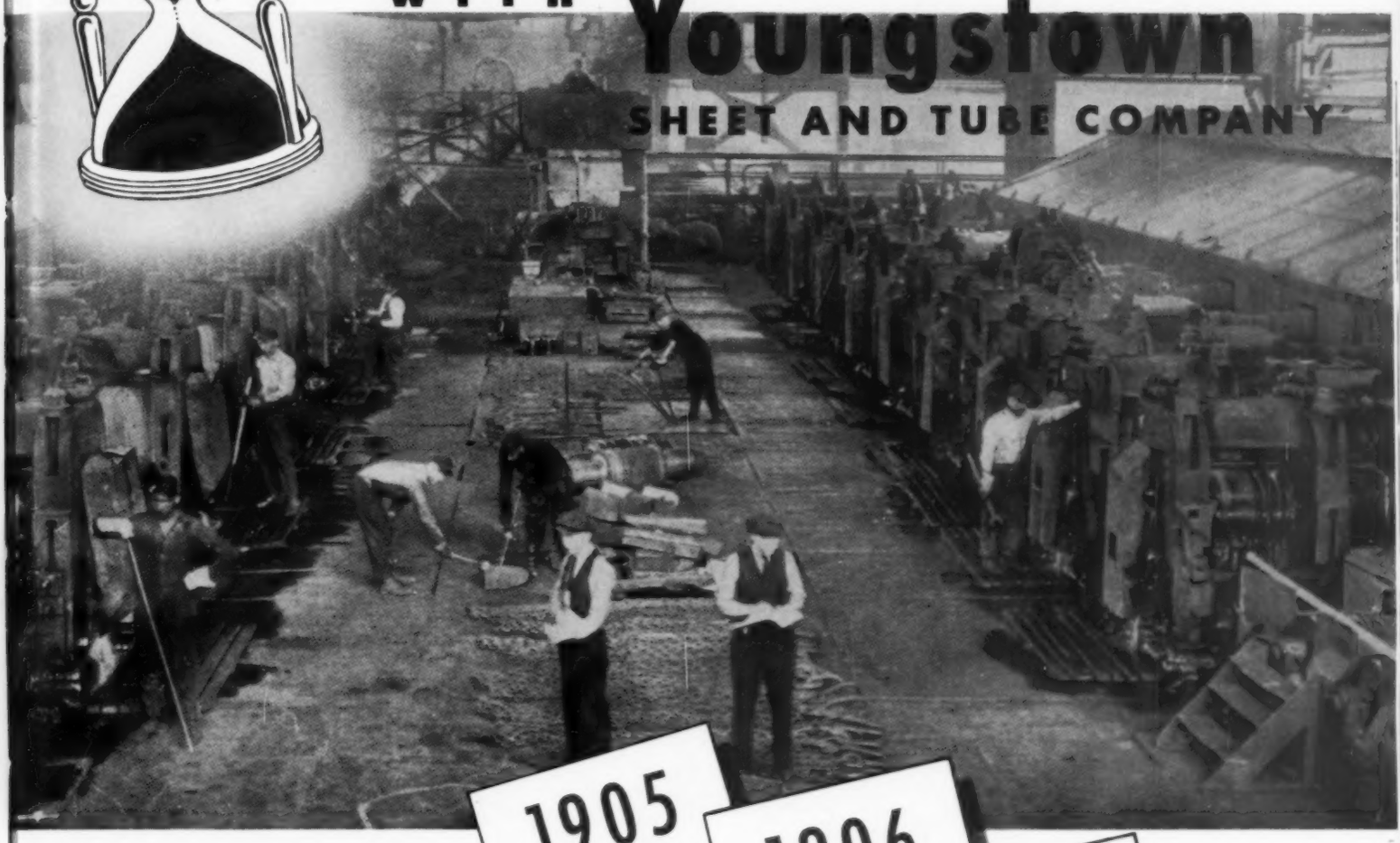
50 YEARS of association WITH Youngstown SHEET AND TUBE COMPANY



1905 SHEET BAR MILL AND BILLET MILL

1906 SKELP MILL

1915 MERCHANT MILL

1923 BILLET MILL

1928 MERCHANT MILL

1929 BILLET AND SLAB MILL

1940 BILLET AND SLAB MILL

1955 MORGOIL BEARINGS

MORGAN WORCESTER

The picture above shows Morgan's first installation for Youngstown, in 1905. The mill on the right is a continuous billet mill, at the left a continuous sheet bar mill.

Through the years, ever since 1905, the Morgan Construction Company has enjoyed the privilege of working with the Youngstown Sheet and Tube Company. Today, 50 years later, the Morgan Construction Company is still contributing to the growth and efficiency of a greatly expanded Youngstown organization. Installations of Morgan equipment have not only included the number of mills listed above, but also many specially designed auxiliary units.

One point seems obvious—in order to have this association last for a half-century, Morgan has produced the best possible equipment designed to do the best possible job of production.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

Rolling Mills - Morgoil Bearings - Wire Mills
Regenerative Furnace Control - Ejectors - Gas Producers

English Representative
International Construction Co., 56 Kingsway, London, W. C. 2, England

RM-66

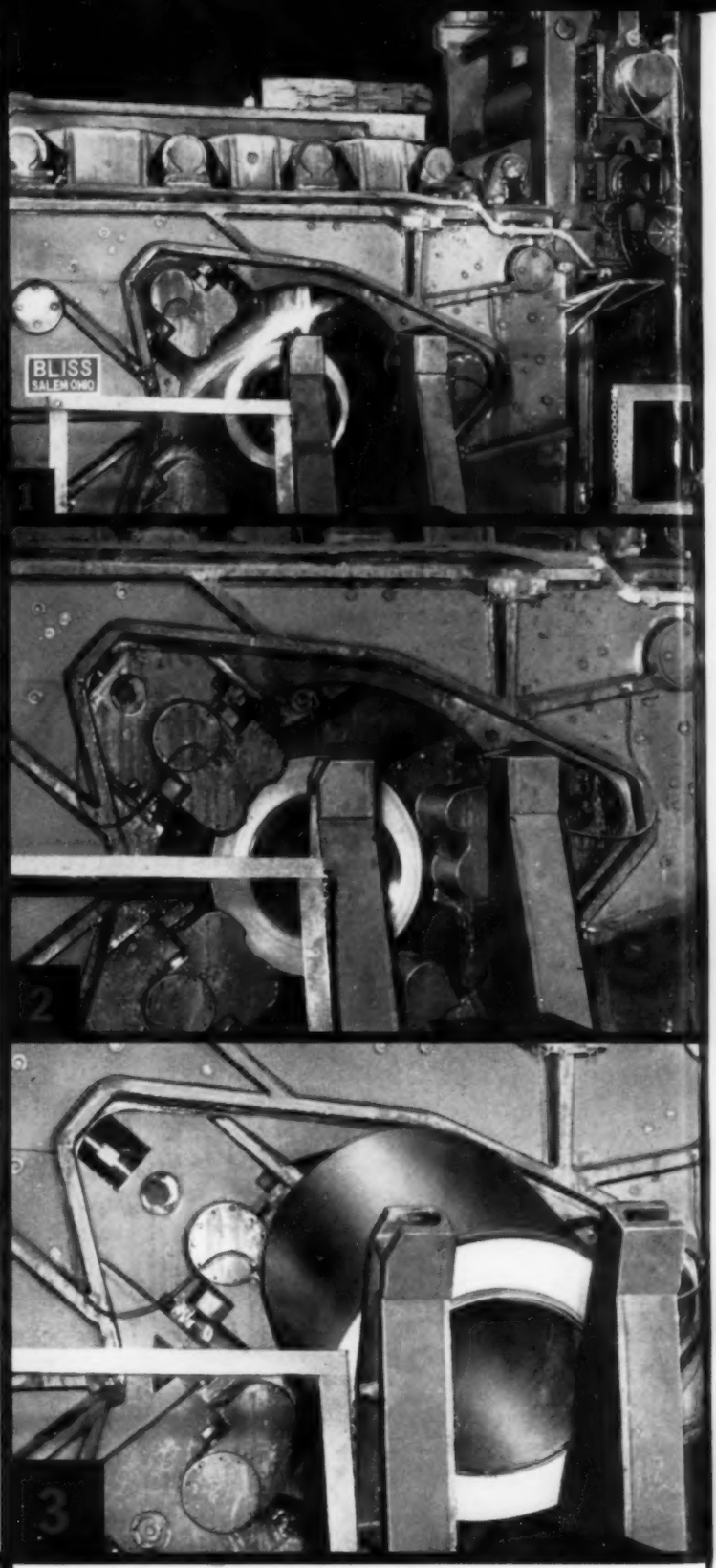
At Youngstown's Indiana Harbor Works...

A NEW BLISS DOWNCOILER FOR BOOMING HOT STRIP MILL

A recently-installed Bliss downcoiler is helping the hot strip department at Youngstown Sheet & Tube's Indiana Harbor Works reduce the strain of maintaining record output levels that have hovered at or near capacity for months. The new Bliss unit increases downcoiler capacity 50%, lightens the load on two older downcoilers.

This is the latest in a series of downcoiler installations in American and foreign steel plants dating from Bliss' development of the expanding mandrel design. The advantage of the expanding mandrel is that the strip end is held firmly during coiling. Thus, the coil is tight, solid and smooth-edged. When coiling has been completed, the mandrel collapses, freeing the coil for easy ejection onto the upender. Surface damage is eliminated: blocker roll controls permit the operator to pull the rolls back from the coil as soon as the mandrel picks up the snubbed end of the strip. The rolls do not touch the strip again until the trailing end is about to be taken up, thus supplying a tightly wrapped coil throughout.

Bliss hot mill downcoilers can be built for any practical strip width and gage, coil weight and run-out speed. If you would like more information about them ... and about other important Bliss rolling mill developments... write for a free copy of our 60-page Rolling Mill Brochure, Catalog 40-A.



Tight coils without surface damage!

1. Red hot 54" strip traveling 1700 fpm is taken up on mandrel of new Bliss downcoiler at Indiana Harbor Works. Note that blocker rolls are retracted, leaving plenty of clearance. Expanded mandrel grips I.D. of coil firmly, maintaining tension on the strip.

2. Blocker rolls move in as trailing end of strip comes through pinch rolls (upper right), at end of run-out table.

3. Eight-thousand-pound coil is easily stripped from the collapsed mandrel segments. Note smooth edges and tight winding. Upender is beginning to transfer coil to conveyor station, where it will be banded and marked with heat number.

E. W. BLISS COMPANY, General Office: Canton, Ohio
ROLLING MILL DIVISION, SALEM, OHIO

BLISS
SINCE 1857

Bliss is more than a name... it's a guarantee

Presses, ROLLING MILLS, Special Machinery

PLANTS: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California
E. W. Bliss (England) Ltd., Derby — E. W. Bliss Co. (Paris), France

7 of the 8 open hearths in No. 2 shop at Indiana Harbor have Ramset bottoms

YOUNGSTOWN Sheet and Tube is making steel on 7 Ramset bottoms in its No. 2 open hearth shop at the Indiana Harbor Works.

The majority of bottoms installed in new open hearth shops during the past several years are of rammed construction. And of these hearths, Ramset installations number more than half again as many as any other magnesia ramming mix.

Basic Refractories pioneered the development of rammed hearth techniques several years before World War II. These methods have been continuously refined by the practical steelmakers who form the sales and service staff of Basic Refractories. As a result Ramset and Basic's installation techniques have become accepted as standard throughout the industry.

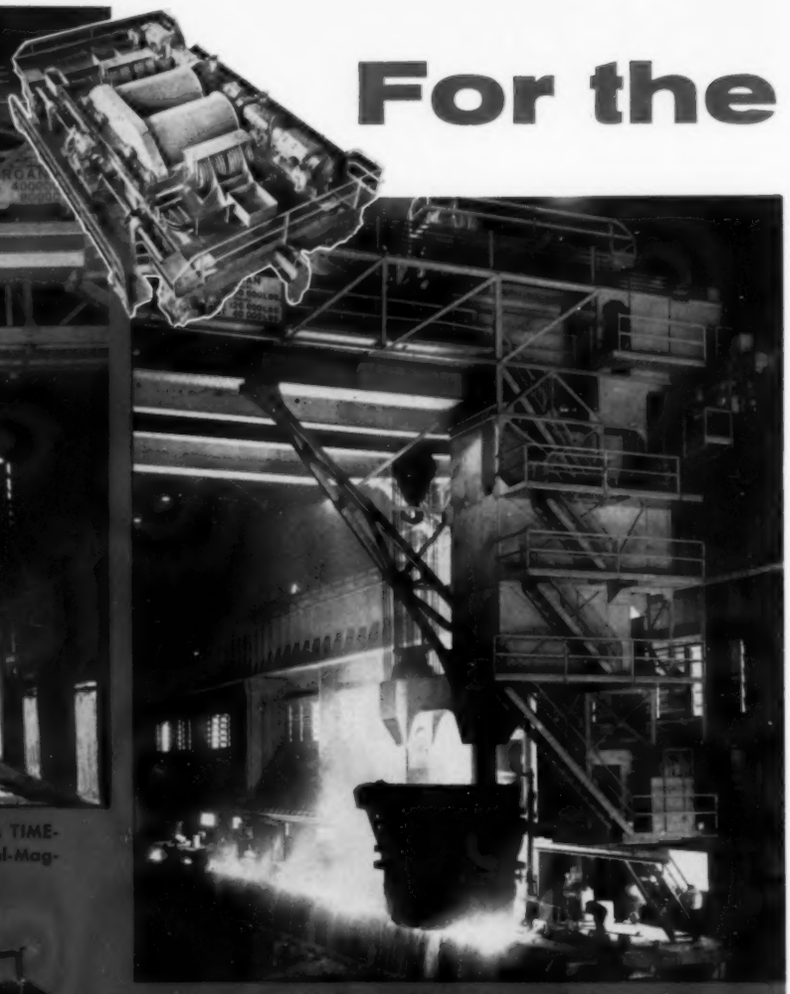
When deciding upon Ramset steelmakers select a proven refractory and proven installation methods, thus insuring the most dependable open hearth bottom construction available.

BASIC REFRACTORIES INCORPORATED 845 HANNA BUILDING, CLEVELAND 15, OHIO

REFRACTORIES ENGINEERING AND SUPPLIES, LTD. — EXCLUSIVE CANADIAN AGENTS

For the

200-Ton Stripper Crane, completely equipped with EC&M TIME-CURRENT Controllers, WB Brakes, Limit Stop and Manual-Magnetic Disconnect Switch.



'Jumping' quickly from mold to mold is easily done with EC&M TIME-CURRENT Control on this 350-Ton Ladle Crane (photo-inset above shows trolley).

New Scale Car with EC&M Control. Existing Scale and Transfer Cars have been operating economically for several years under EC&M Control.

Coal Bridge Trolley is equipped with EC&M Factory-assembled TIME-CURRENT, LINE-ARC Contactor Controllers.

12-Ton Charging Machine and 150-Ton Hot Metal Crane use EC&M Control for fast, accurate and dependable performance.

Installation Photos, courtesy of Youngstown Sheet & Tube Company

tough jobs in STEEL...

Control excels

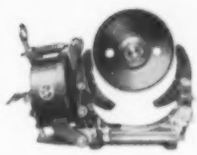
The BIG jobs in steel-making are tough . . . and vital. Safe operation is foremost, but equally important are dependability, economy and ability to give rapid response on short moves when needed. EC&M TIME-CURRENT Acceleration excels in taking the swing out of the ladle when jumping from mold to mold.

On major steel-producing operations, performance proves that EC&M Control is *accurately engineered* and gives the greatest service with lowest maintenance. Look at the proof of acceptance of EC&M Control for the tough jobs shown here.

You'll find, as others have, that EC&M Control is simplest . . . and has maximum safety advantages. Make your next job EC&M equipped by specifying "EC&M Control".

EC&M makes COMPLETE CONTROL
for Chargers • Cranes • Bridges • Cars • Mill Auxiliaries

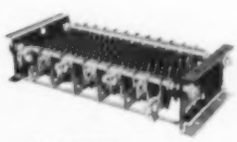
YOUNGSTOWN SAFETY LIMIT STOP
Bulletin 1032.



LONG-LIFE BRAKES for A-c and D-c Cranes.
Bulletin 1004.

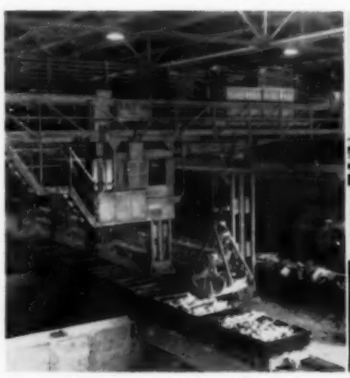
MAGNETIC CONTROLLERS
Bulletin 921.

CAM MASTER SWITCHES
Bulletin 1190.

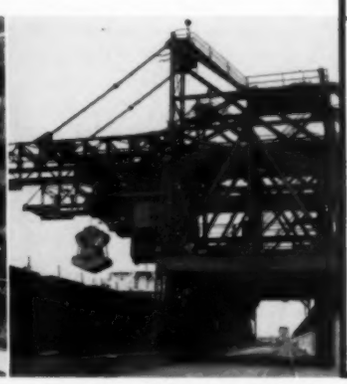


TAB-WELD Plate Resistors
Bulletin 942.

DISCONNECT SWITCHES
Bulletin 1023.



Bucket-Crane in Stockhouse is EC&M equipped.



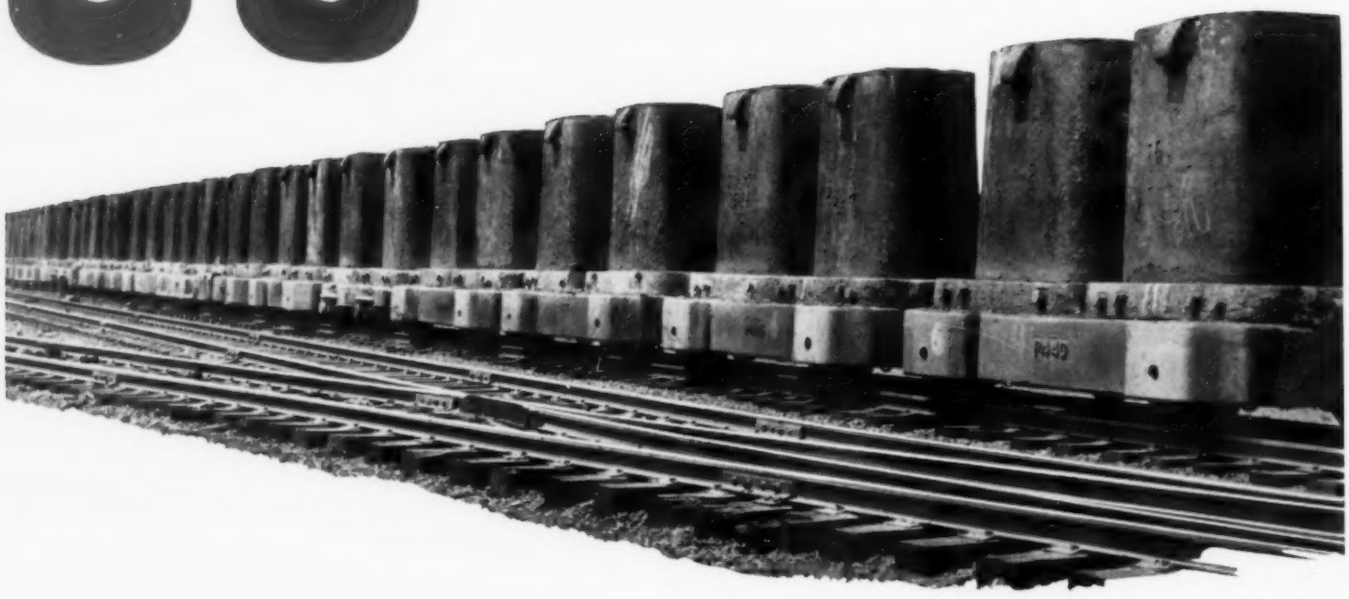
One of two 8-Ton Ore Unloaders, EC&M Controlled.

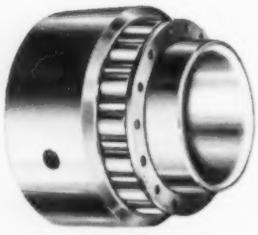
THE ELECTRIC CONTROLLER & MFG. CO.
4498 Lee Road • Cleveland 28, Ohio

6544

86% OF ALL INGOT CARS ROLL ON RUGGED HYATTS

at the Indiana Harbor Works of Youngstown Sheet and Tube





In this great mill, *as throughout the steel industry*, HYATTS are far and away the *preferred* roller bearings for ingot cars.

Why this overwhelming preference? There are six sound reasons:

1. HYATTS greatly reduce friction and starting power requirements
2. HYATTS permit longer trains, faster and smoother car spotting
3. HYATTS perform dependably despite constant heating and cooling, abrasive dirt, and pile-driver shocks when ingots are pounded free from the molds by the stripper
4. HYATTS' straight cylindrical design permits lateral expansion without cramping rollers
5. HYATTS provide ample reserve for overloads
6. HYATTS virtually eliminate costly downtime

If you want bearings that can *keep on taking* the most brutal kind of punishment—*can keep your production rolling profitably*—standardize on HYATTS throughout your mill!

HYATT ROLLER BEARINGS

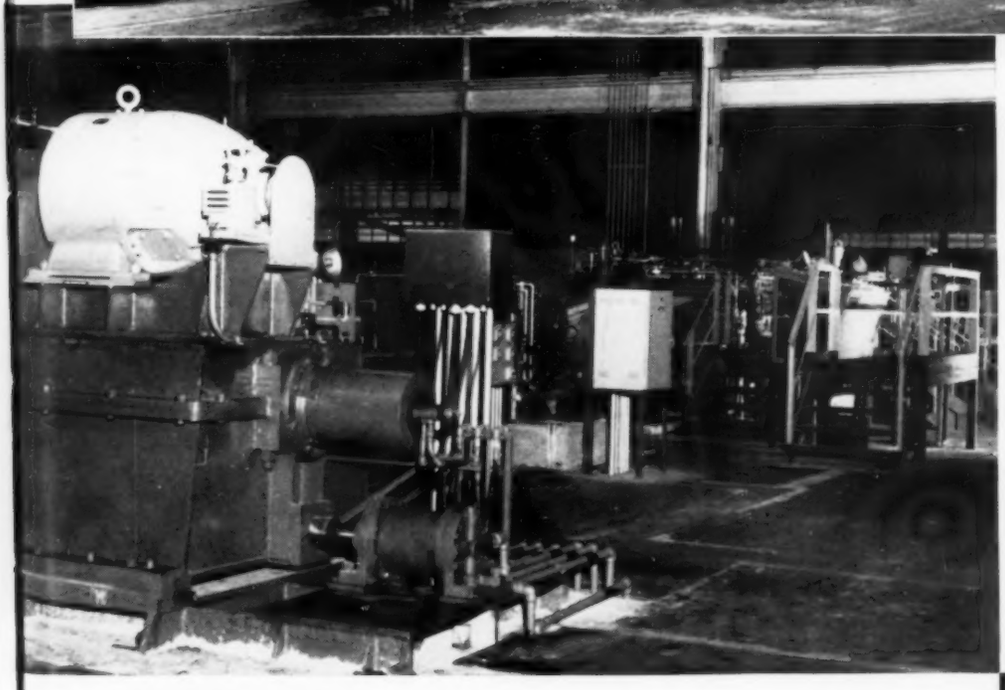
STRAIGHT ▯ BARREL ▯ TAPER ▯

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

WEAN

SHEET, STRIP AND TIN MILL EQUIPMENT IS SPECIFICALLY DESIGNED FOR

INCREASED PRODUCTIVITY



The best advertisement for any product is the testimony of a satisfied customer. When it comes to fully integrated pickling lines, Wean can point to many highly successful installations.

For example, the line in operation at the Indiana Harbor Works of the Youngstown Sheet and Tube Company (shown here) — where high grade pickling is essential—has been delivering a product of the highest quality, consistently, since installation.

When next you're considering pickling equipment why not talk it over with Wean engineers and get the one line that is designed for increased productivity, economy and ease of maintenance.

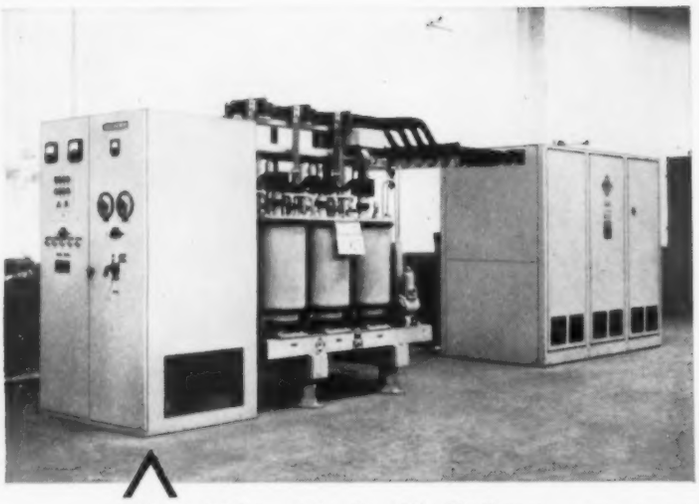
The WEAN **ENGINEERING CO., INC.**

WARREN, OHIO

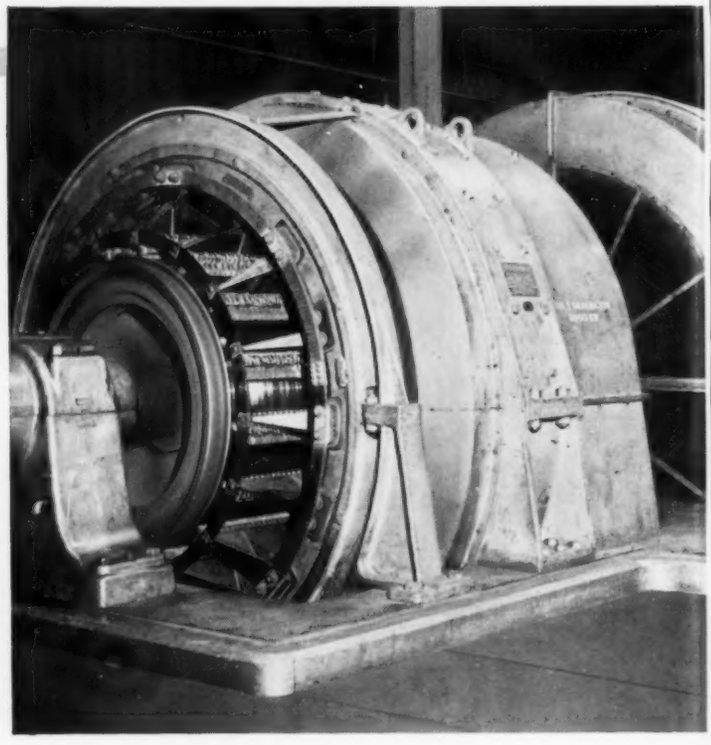
SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

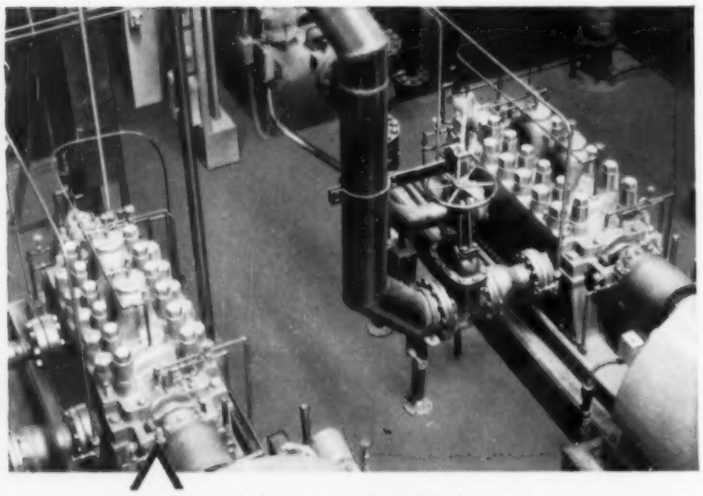
Helping Youngstown Top Steel Year After

ALLIS-CHALMERS Steel Mill EQUIPMENT



This 1000-kw, 250-volt Allis-Chalmers mercury arc rectifier furnishes direct current to cold mill auxiliaries. An additional low-first-cost, high efficiency unit of this type and capacity is being installed in the tin mill.



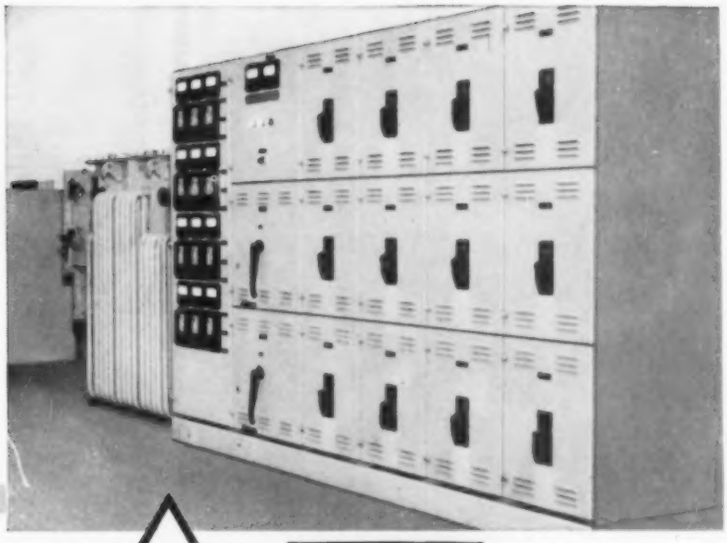


Two 6 by 4 five-stage Allis-Chalmers descaling pumps rated 1000 gpm, 1140 psi. Allis-Chalmers has also furnished fire pumps, motors and controls for other applications at the Indiana Harbor mill.

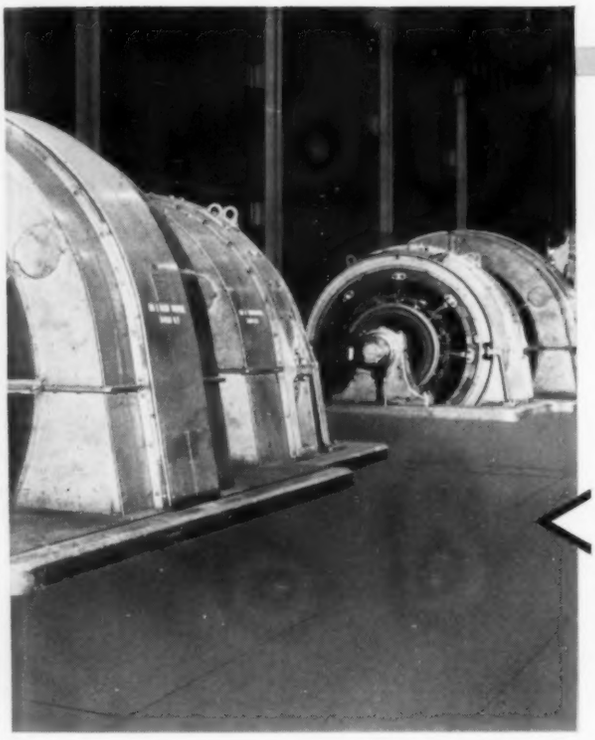
Equipment Installed in 1940 Still Going Strong as new Equipment is Added to Keep Pace with Today's Production and Quality Requirements

A-C ALLIS-CHALMERS **ALLIS-**

Obtain Production Year



Allis-Chalmers 1000-kva, 440-volt substation serves the cold mill at Youngstown's Indiana Harbor Works. Unit has non-flammable *Chlorextol* liquid-filled transformer. Additional substations of larger capacity are now being furnished for expansion at this plant.



These two Allis-Chalmers 6000-kw, 600-volt motor-generator sets supporting the 54-inch hot strip mill have been operating at rated capacity and above for 15 years — with minimum maintenance.

SWITCHGEAR, transformer, substation, and rectifier equipment was recently added to the growing list of Allis-Chalmers installations at The Youngstown Sheet and Tube Company's Indiana Harbor Works. These Allis-Chalmers units were specified for the new cold mill that is part of the major expansion program at the Indiana Harbor plant.

For many years, Allis-Chalmers equipment has served Youngstown well. Motor-generator sets, motors, pumps, *Texrope* drives, transformers, switchgear—all have been supplied over the years to help keep production at The Youngstown Sheet and Tube Company plants modern, flexible and economical.

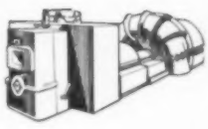
You too can take advantage of the wide range of Allis-Chalmers products and superior service . . . backed by experience gained serving the steel industry since the days of the famed Corliss engine drives. For help in planning new facilities or modernizing present plants, contact the A-C office in your district, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4836

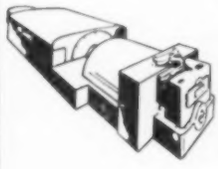
CHALMERS

Other Allis-Chalmers Equipment for the Steel Industry

Wide Range of Motors for main mill and auxiliary drives — ac or dc — from 1 hp to 10,000 hp — and supporting rectifiers or m-g sets.

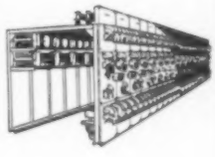
Blast Furnace Blowers are an important part of the complete A-C line of single and multi-stage centrifugal blowers, axial and rotary compressors, and vacuum pumps for the steel industry.





Power Generation Equipment includes steam turbine-generator units 2000 kw and larger for fluctuating steel mill loads. Also condensers, pumps and auxiliary drive motors.

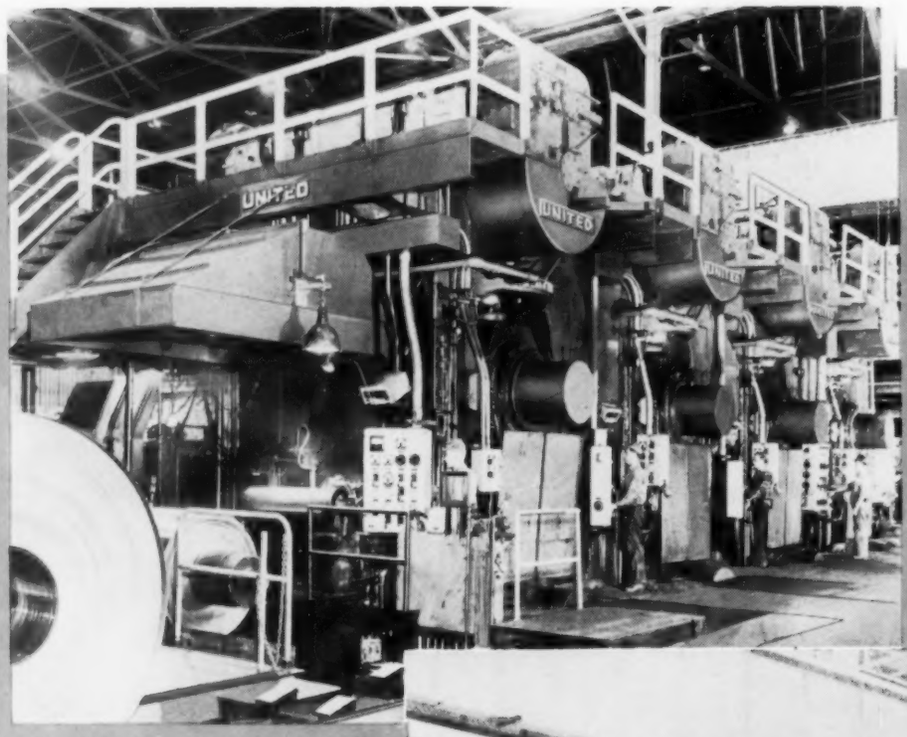
Steel Mill Control offered by Allis-Chalmers includes constant potential and variable voltage systems, magnetic amplifier, electronic and mechanical regulators, and liquid rheostats.



Chlorextol and *Texrope* are Allis-Chalmers trademarks.

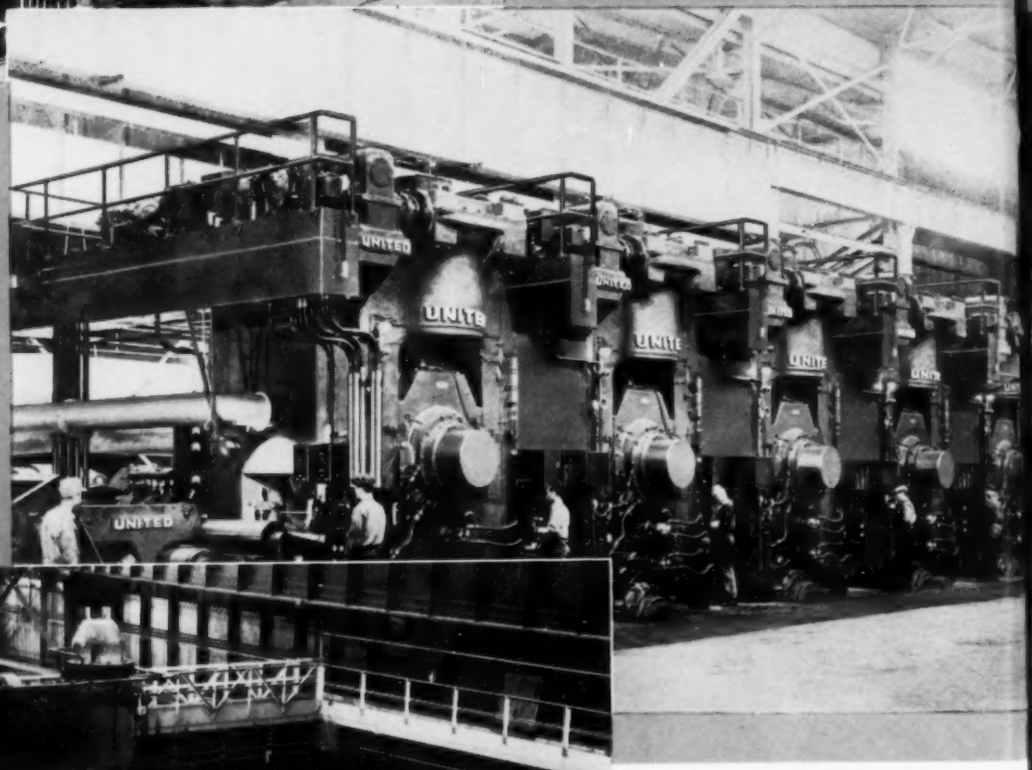
UNITED® MILLS

in Service . . .

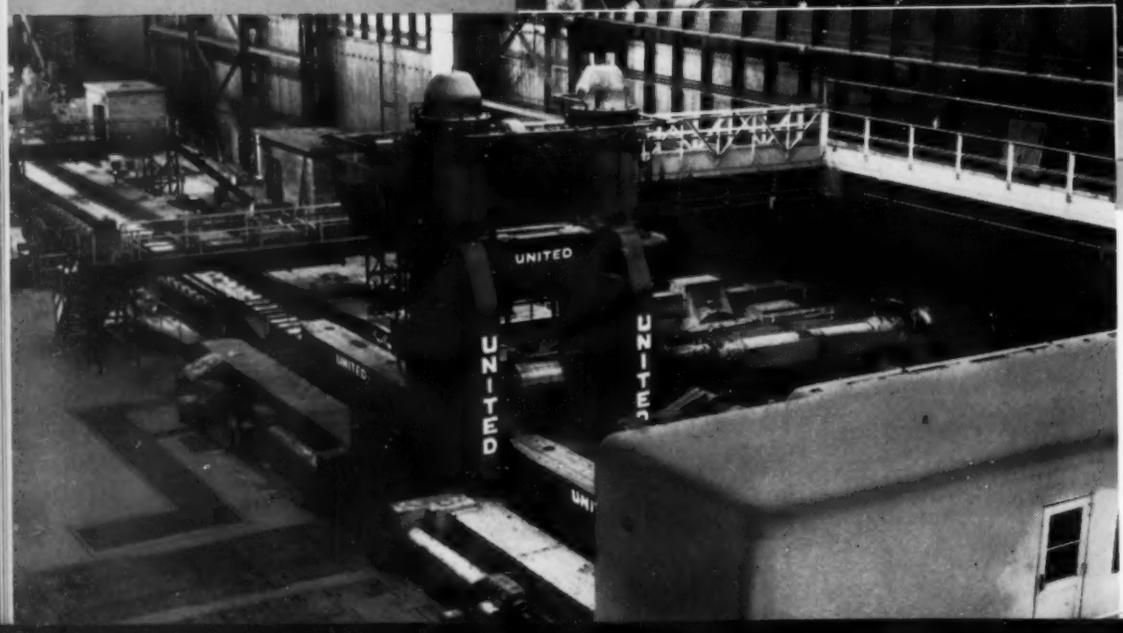


21" & 56" x 56"

4 High
4 Stand Tandem
Cold Mill



18" & 49" x 48"
4 High 5 Stand
Tandem Cold Mill



46" x 115"
Slabbing Mill

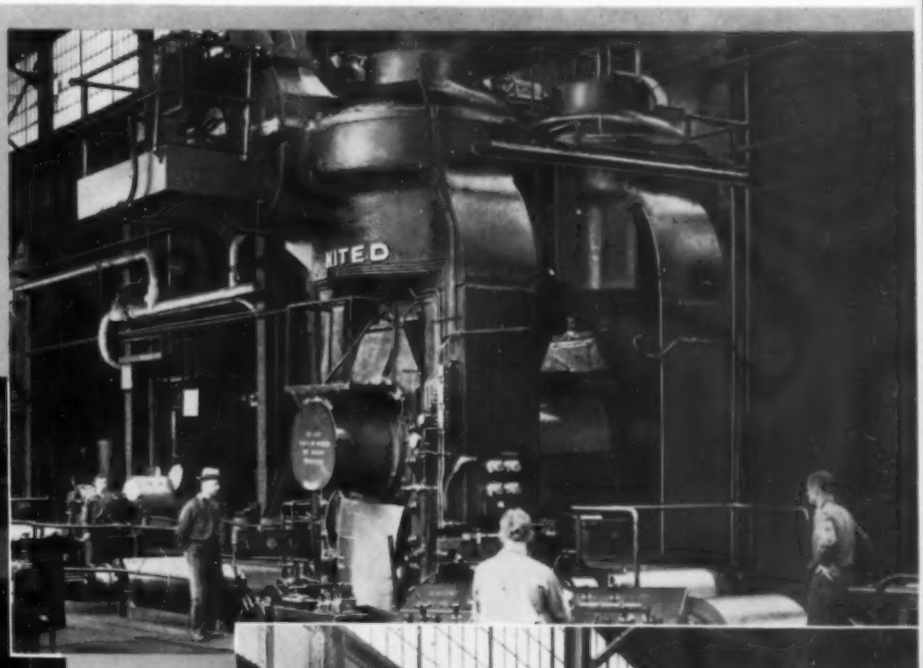
at the INDIANA HARBOR PLANT of

THE YOUNGSTOWN SHEET & TUBE COMPANY

16½" & 49" x 42"

4 High

Reversing Cold Mill



46" x 100"

Blooming Mill

2 Stand Tandem

4 High

Skin Pass Mill

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at Pittsburgh • Vandergrift • Youngstown • Canton
Wilmington (Lobdell United Division)

Subsidiaries: Adamson United Company, Akron, Ohio
Stedman Foundry and Machine Company, Inc., Aurora, Indiana

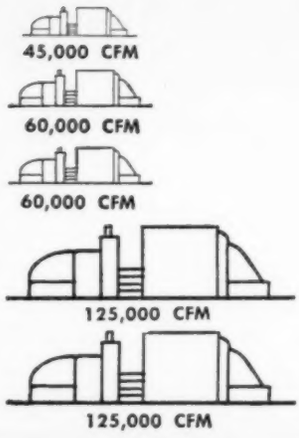
Designers and Builders of Ferrous and Non-Ferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery, Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

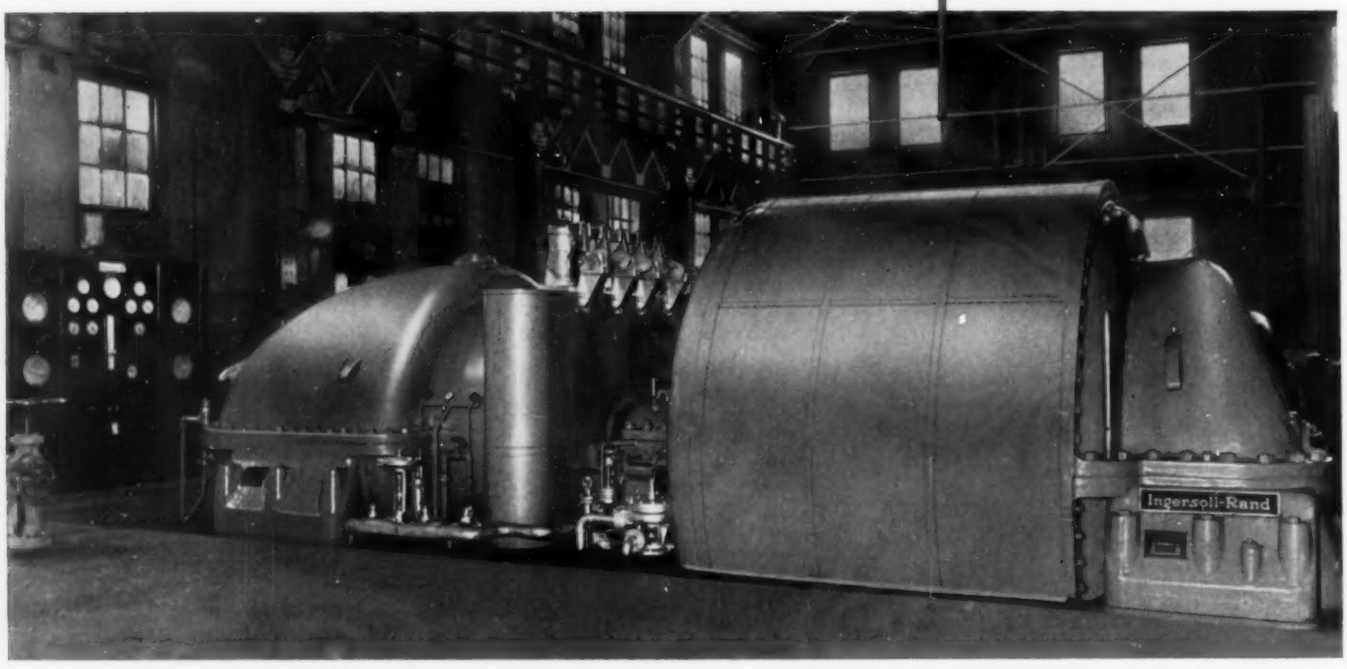
®

FIVE I-R BLAST FURNACE BLOWERS

now in service at

Youngstown Sheet and Tube Company's Indiana Harbor Plant





The first I-R Blast Furnace Turbo-Blower installed at Indiana Harbor is still in daily service after 38 years of operation.

Six additional Blast Furnace Blowers in other Youngstown Sheet and Tube Co. plants bring the total to 11 units representing 760,000 cfm capacity.

PAST EXPERIENCE is one sure way of predicting future performance.

That's why the Youngstown Sheet and Tube Company continues to select I-R blast furnace turbo-blowers with *complete confidence* in their ability to give years of continuous, trouble-free service. For this steel company knows what I-R blowers can do — based on 38 years of actual operating experience. The first I-R blast furnace blower at the Indiana Harbor plant was installed in 1917 — and it's still on the job today.

The last two I-R Turbo-Blowers installed at Indiana Harbor, each rated 125,000 cfm, 35 psi discharge, are served by Ingersoll-Rand condensers, condensate pumps and circulating water pumps. Other Ingersoll-Rand equipment includes air compressors for plant air supply, instrument air and soot blowing, boiler-feed pumps and many other pumping units for miscellaneous plant service.

For proved *dependability* in steel mill equipment, it pays to specify Ingersoll-Rand. Your nearest I-R representative will be glad to discuss your requirements.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N.Y.

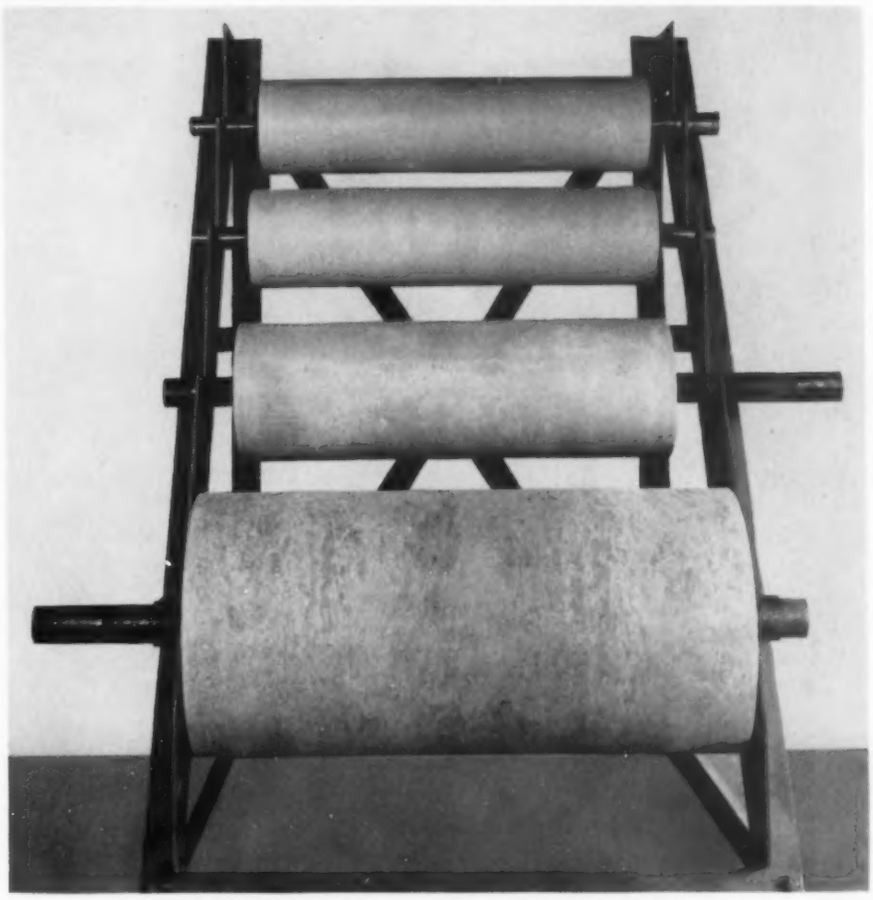
12-278

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

SPEC PLASTIC ROLLS—

MIRACLE MATERIAL USED ON TIN MILL COVERED ROLLS FOR HEAT, ABRASION, ACID, WATER, OIL, ETC.

- annealing
- pickling
- scrubbing
- finishing
- electro-tinning



(TOP) PINCH ROLL, SPEC LB-RM-105 MATERIAL
(SECOND) GUIDE ROLL, SPEC LB-RM-105 MATERIAL
(THIRD) LOOPER ROLL, SPEC LB-RM-105 MATERIAL
(BOTTOM) BRIDLE ROLL, SPEC GL5-RM-110 MATERAL

SPEC SYNTHETIC ROLLS for YOUNGSTOWN SHEET & TUBE COMPANY, INDIANA HARBOR WORKS TIN MILL DIVISION

These rolls outlast their predecessors from 3 to 5 times under various conditions.

Rolls such as these are making it possible for maintenance and production to realize more dollar-value per roll per application than ever before.

STRENGTH, DURABILITY, and LIFE never before achieved in the Cover Roll Industry.

Write, wire, or phone for details and applications.

STEEL PLANT EQUIPMENT CORPORATION

Specialists in Covered Rolls

3117 Grant Building · Pittsburgh 19, Pa. · EXpress 1-3277

Representatives:

T. A. REILLY COMPANY.....139 N. Clark St., Chicago 2, Illinois
Phone — Franklin 2-3474

J. E. KIEFER COMPANY.....P. O. Box 3193, Youngstown 12, Ohio
Phone — Sterling 2-6386

DeSHAZO-THOMAS..107 Broadway, P. O. Box 5822, Birmingham 9, Ala.
Phones — Tremont 1-4127; Tremont 9-6610

EMPIRE ENG. CO.....385 East Green Street, Pasadena 1, California
Phone — Ryan 1-6178

A. M. McINTYRE.....8226 Buchanan Street, St. Louis 14, Missouri
Phone — Harrison 83940

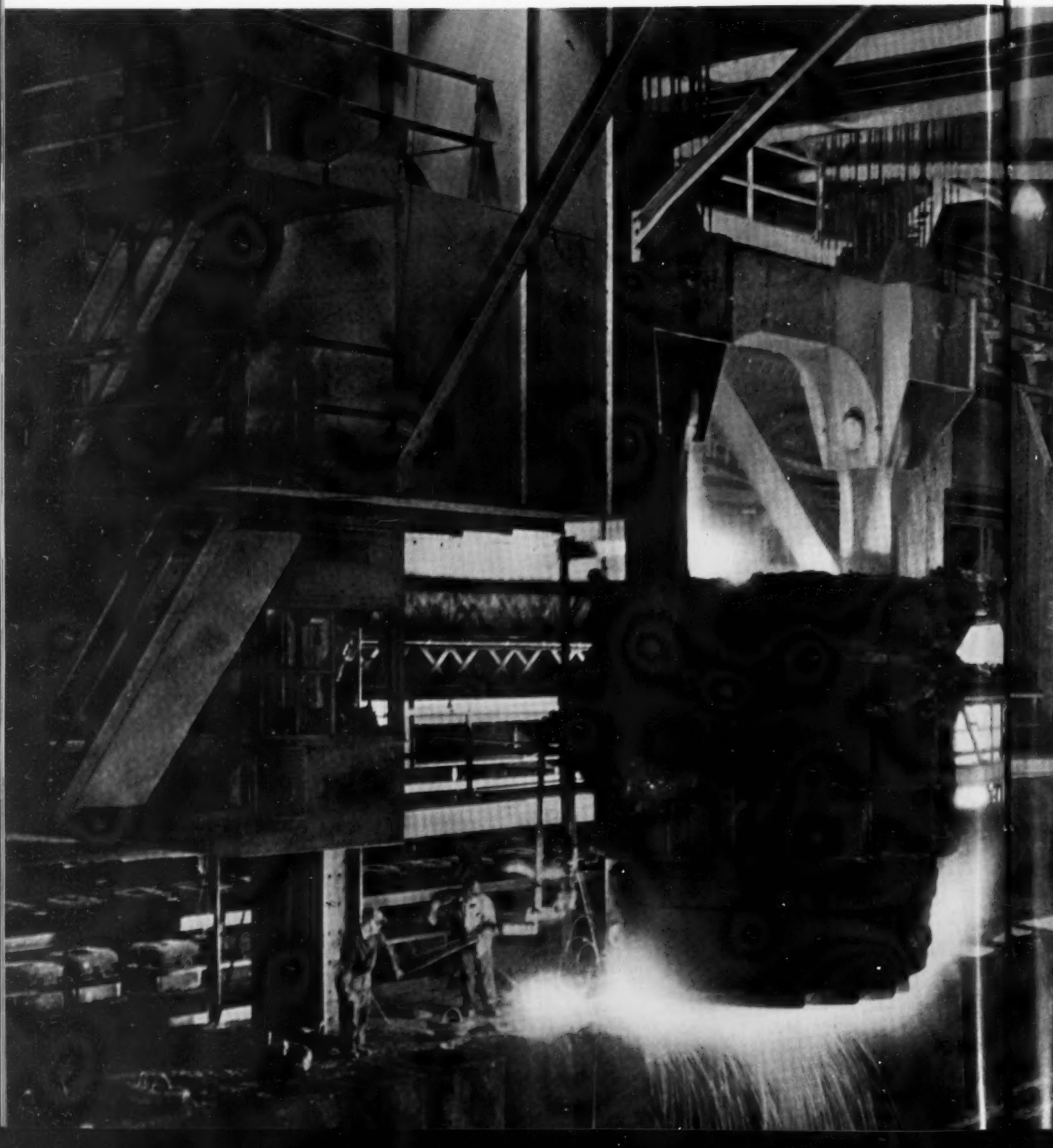
HIGGINSON ENGINEERING CO.....275 James St. North, P. O. Box 23, Hamilton, Ontario, Canada

THOMAS J. DEMPSEY, JR.....321 Investment Bldg., Pittsburgh 22 Pa.
Phone — Grant 1-8370

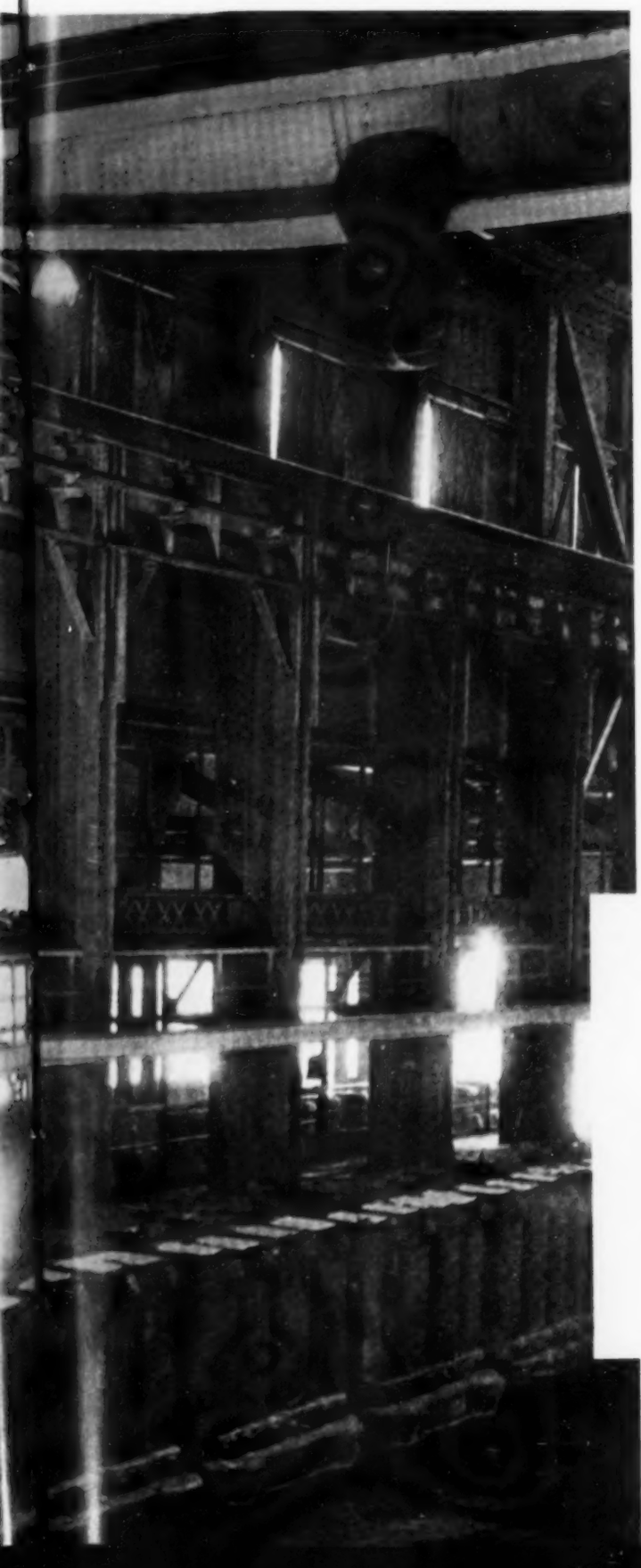
STEEL PLANT EQUIPMENT CORP.....Room 50, Curren Arcade Bldg., Norristown, Pa.
Phone — Norristown, Pa. 5-7539

For Youngstown Sheet & Tube . . .

KOPPERS designed and



engineered 8 new open hearths



A SIGNIFICANT PHASE of the recent expansion of steel-producing capacity by The Youngstown Sheet & Tube Company was the addition of a new open-hearth shop at its Indiana Harbor plant.

This open-hearth shop, with eight furnaces, was designed and engineered by the steel plant specialists of Koppers Freyn Department, who also engineered the installation of a complete slabbing mill at this plant during the same expansion program.

Design of the main open-hearth furnace building would permit the eventual addition of four more furnaces, if needed.

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Designing and constructing open hearths is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers. You are invited to consult with our Engineers and Management.

KOPPERS®

Engineering and Construction Division

FREYN DEPARTMENT

KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA

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H. H. Robertson Co. is proud to have supplied this great plant since 1916

Robertson Galbestos—Improved protected metal sheets for siding and roofing.

Robertson Ventilators—Gravity or fan type, for efficient air movement.

Robertson Q-Floor—Structural subfloor which provides complete electrical availability.

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This is another of the country's leading steel companies whose far-sighted management has realized the economy of an investment in long-lived, maintenance-free construction materials.

H. H. Robertson Company

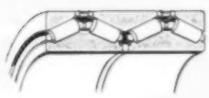
2400 Farmers Bank Building · Pittsburgh 22, Pa.

In England: Robertson Thain Ltd., Ellesmere Port, Cheshire
In Canada: Robertson-Irwin Ltd., Hamilton, Ontario

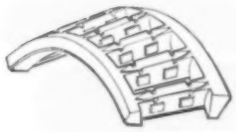
Offices in All Principal Cities World-Wide Building Service

Here's why **TORRINGTON** work roll bearings establish rolling mill records

Highest quality electric furnace alloy steels are used—carburized and heat treated to provide toughness, hardness, stability and uniformity.



Torrington Work Roll Bearings are designed and built with high thrust capacity to give better service under actual operating conditions.



One-piece cast-bronze cages with machined pads in each roller pocket reduce wear, lengthen bearing life and improve performance.

Accuracy in workmanship is characteristic of all TORRINGTON Bearings. This means a lower cost per ton of your finished product.

Many sizes of TORRINGTON WORK ROLL Bearings are available from stock for immediate shipment.

TORRINGTON WORK ROLL Bearings—both two-row and four-row types—are standard in a wide variety of sizes.

For lower operating costs, greater rolling efficiency, less down time... specify TORRINGTON!

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South Bend 21, Ind. • Torrington, Conn.

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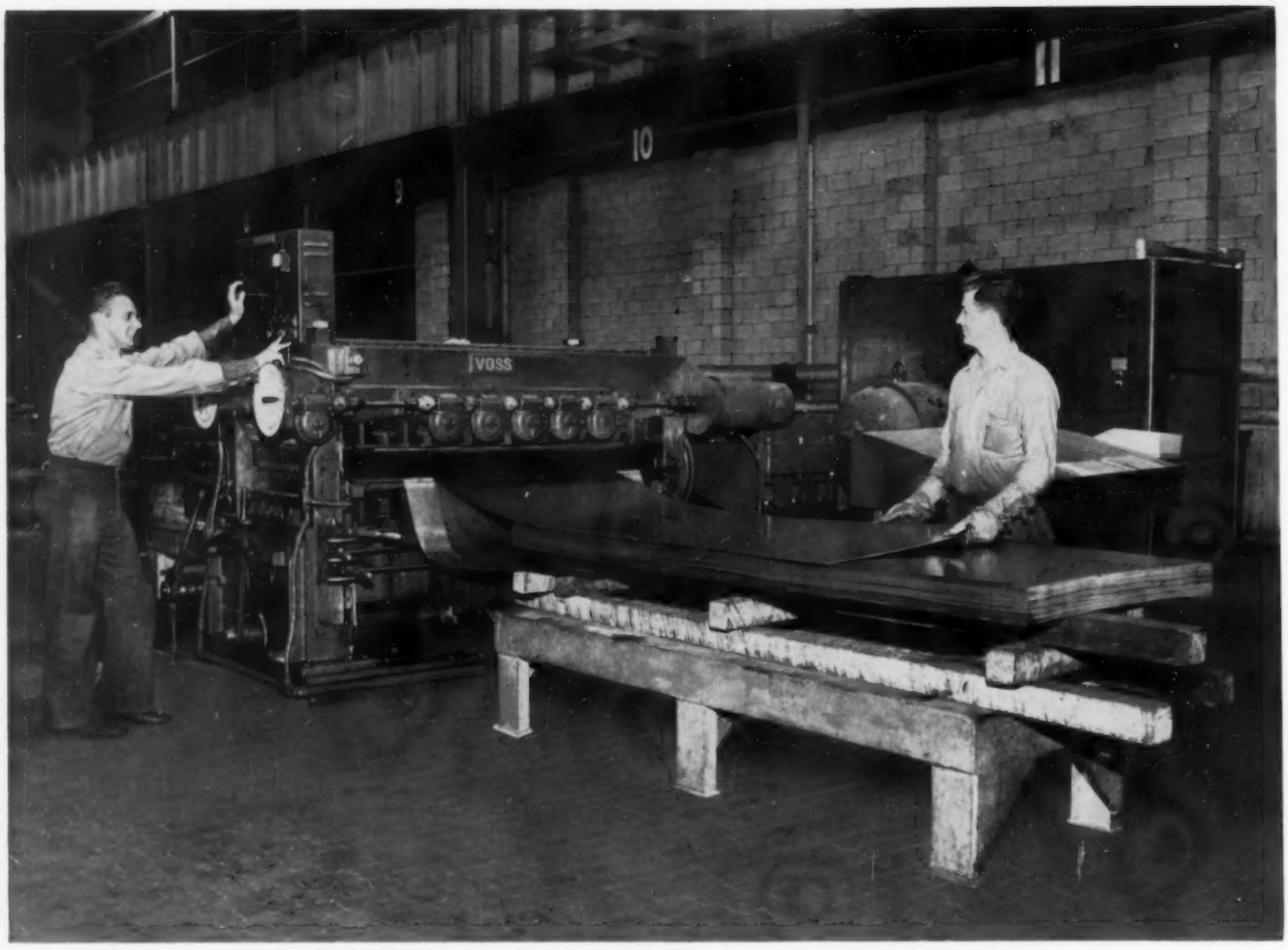
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers



END VIEW OF VOSS PRECISION LEVELER SHOWING COMPLETE OPERATOR'S CONTROLS.

Voss at work
—in Youngstown's Indiana Harbor sheet mill

THIS Voss patented precision leveler, installed at The Youngstown Sheet and Tube Company's Indiana Harbor sheet mill, is designed to flatten hot or cold rolled sheets or strip from 24 to 14 gage, up to 54 in. maximum width. The unit was placed in operation at start of the new sheet mill in 1953.

Thoroughly and scientifically designed, the leveler features simultaneous adjustment. The unit is completely self-contained, including all electrical equipment wired for operation . . . . does not require special foundation . . . . can be moved readily to any plant location.

Voss specializes in the engineering and construction of leveler equipment for ferrous and non-ferrous industries.

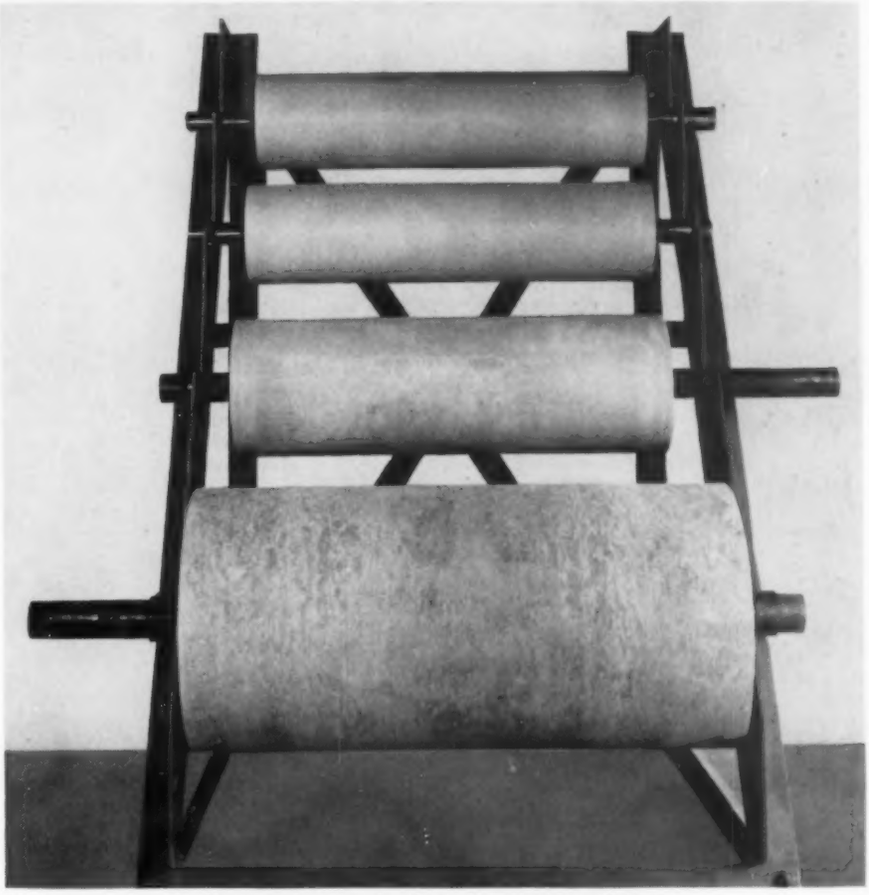
VOSS ENGINEERING CO.

7301 PENN AVENUE • PITTSBURGH 8, PA.

SPEC PLASTIC ROLLS—

MIRACLE MATERIAL USED ON TIN MILL COVERED ROLLS FOR HEAT, ABRASION, ACID, WATER, OIL, ETC.

- annealing
- pickling
- scrubbing
- finishing
- electro-tinning



(TOP) PINCH ROLL, SPEC LB-RM-105 MATERIAL
(SECOND) GUIDE ROLL, SPEC LB-RM-105 MATERIAL
(THIRD) LOOPER ROLL, SPEC LB-RM-105 MATERIAL
(BOTTOM) BRIDLE ROLL, SPEC GL5-RM-110 MATERAL

SPEC SYNTHETIC ROLLS for YOUNGSTOWN SHEET & TUBE COMPANY, INDIANA HARBOR WORKS TIN MILL DIVISION

These rolls outlast their predecessors from 3 to 5 times under various conditions.

Rolls such as these are making it possible for maintenance and production to realize more dollar-value per roll per application than ever before.

STRENGTH, DURABILITY, and LIFE never before achieved in the Cover Roll Industry.

Write, wire, or phone for details and applications.

STEEL PLANT EQUIPMENT CORPORATION

Specialists in Covered Rolls

3117 Grant Building • Pittsburgh 19, Pa. • EXpress 1-3277

Representatives:

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Phone — Franklin 2-3474

J. E. KIEFER COMPANY.....P. O. Box 3193, Youngstown 12, Ohio
Phone — Sterling 2-6386

DeSHAZO-THOMAS..107 Broadway, P. O. Box 5822, Birmingham 9, Ala.
Phones — Tremont 1-4127; Tremont 9-6610

EMPIRE ENG. CO.....385 East Green Street, Pasadena 1, California
Phone — Ryan 1-6178

A. M. McINTYRE.....8226 Buchanan Street, St. Louis 14, Missouri
Phone — Harrison 83940

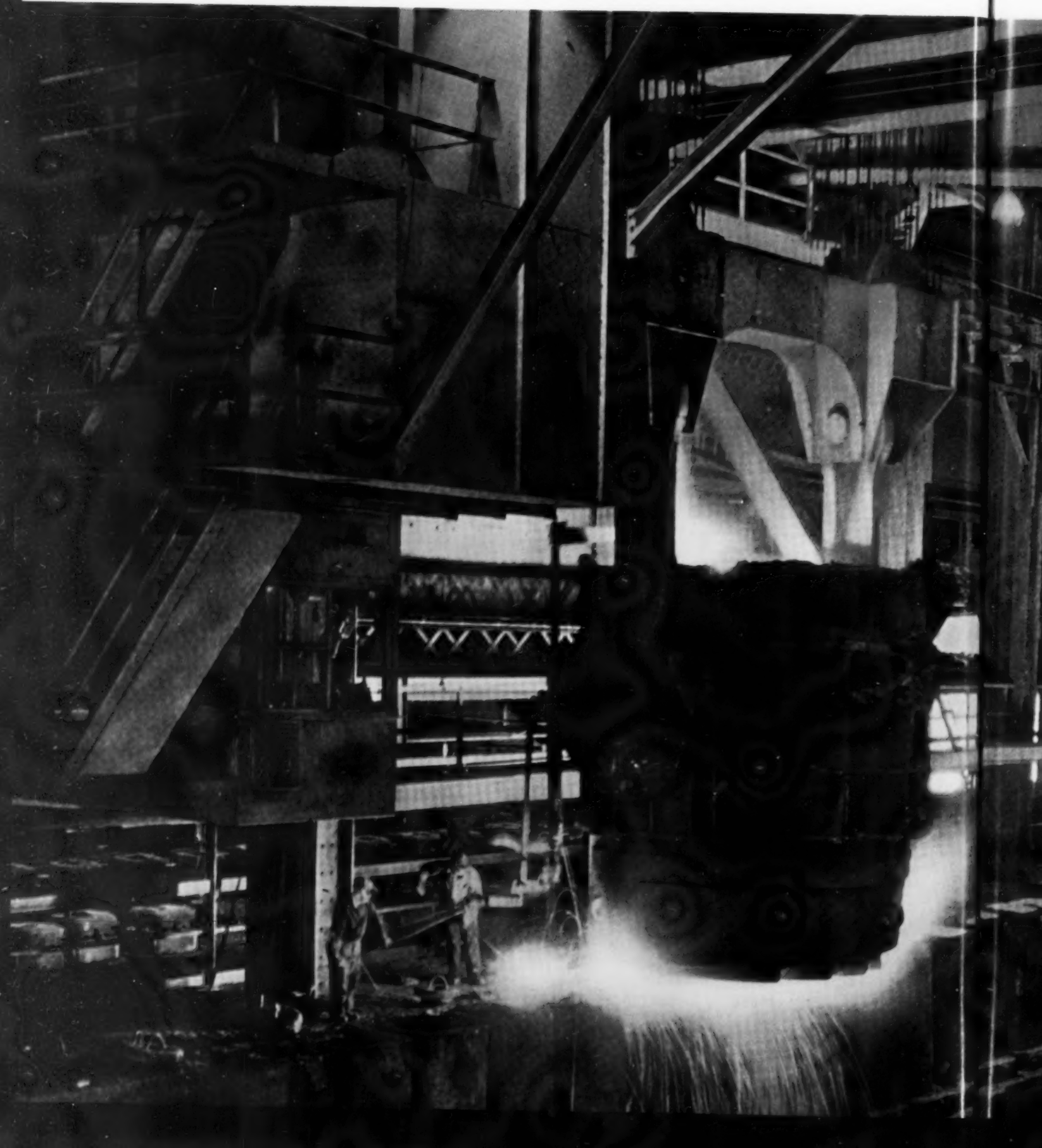
HIGGINSON ENGINEERING CO.....275 James St. North, P. O. Box 23, Hamilton, Ontario, Canada

THOMAS J. DEMPSEY, JR.....321 Investment Bldg., Pittsburgh 22 Pa.
Phone — Grant 1-8370

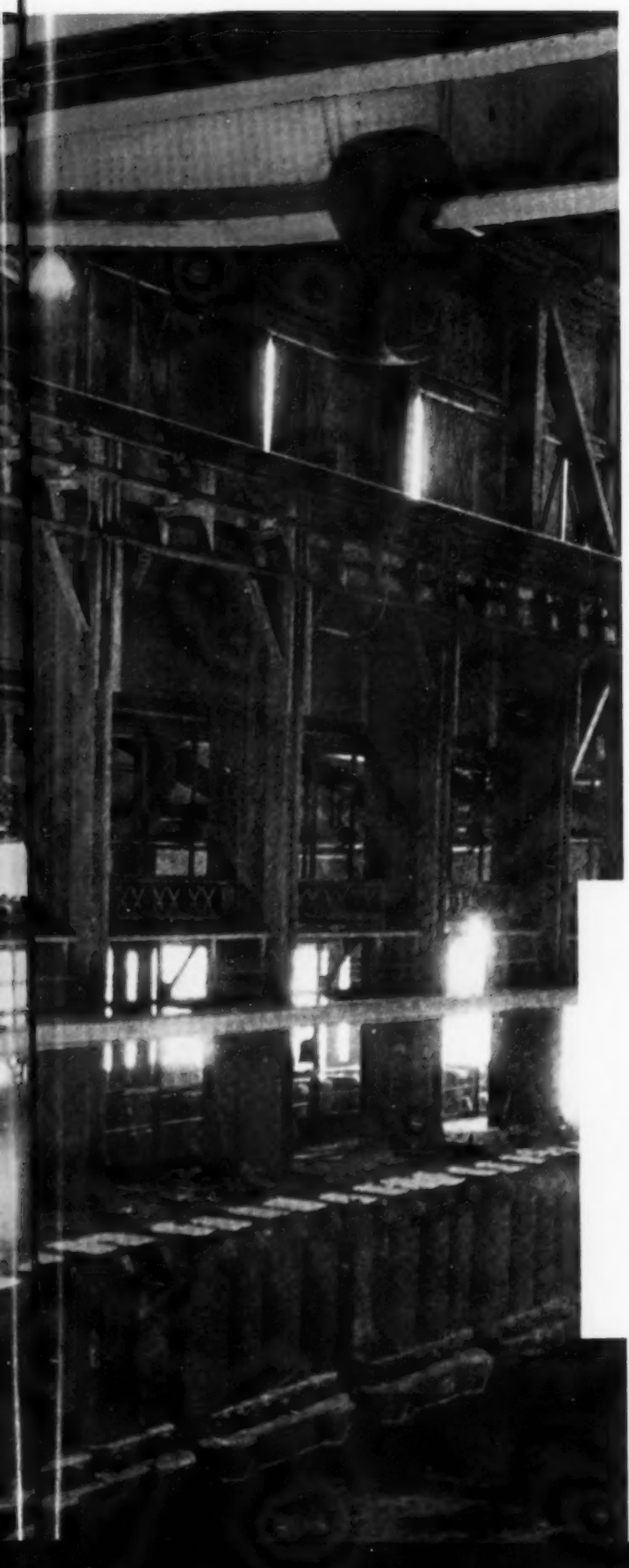
STEEL PLANT EQUIPMENT CORP.....Room 50, Curren Arcade Bldg., Norristown, Pa.
Phone — Norristown, Pa. 5-7539

For Youngstown Sheet & Tube . . .

KOPPERS designed and



engineered 8 new open hearths



A SIGNIFICANT PHASE of the recent expansion of steel-producing capacity by The Youngstown Sheet & Tube Company was the addition of a new open-hearth shop at its Indiana Harbor plant.

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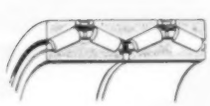

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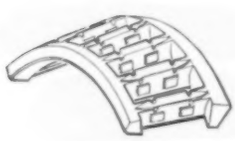

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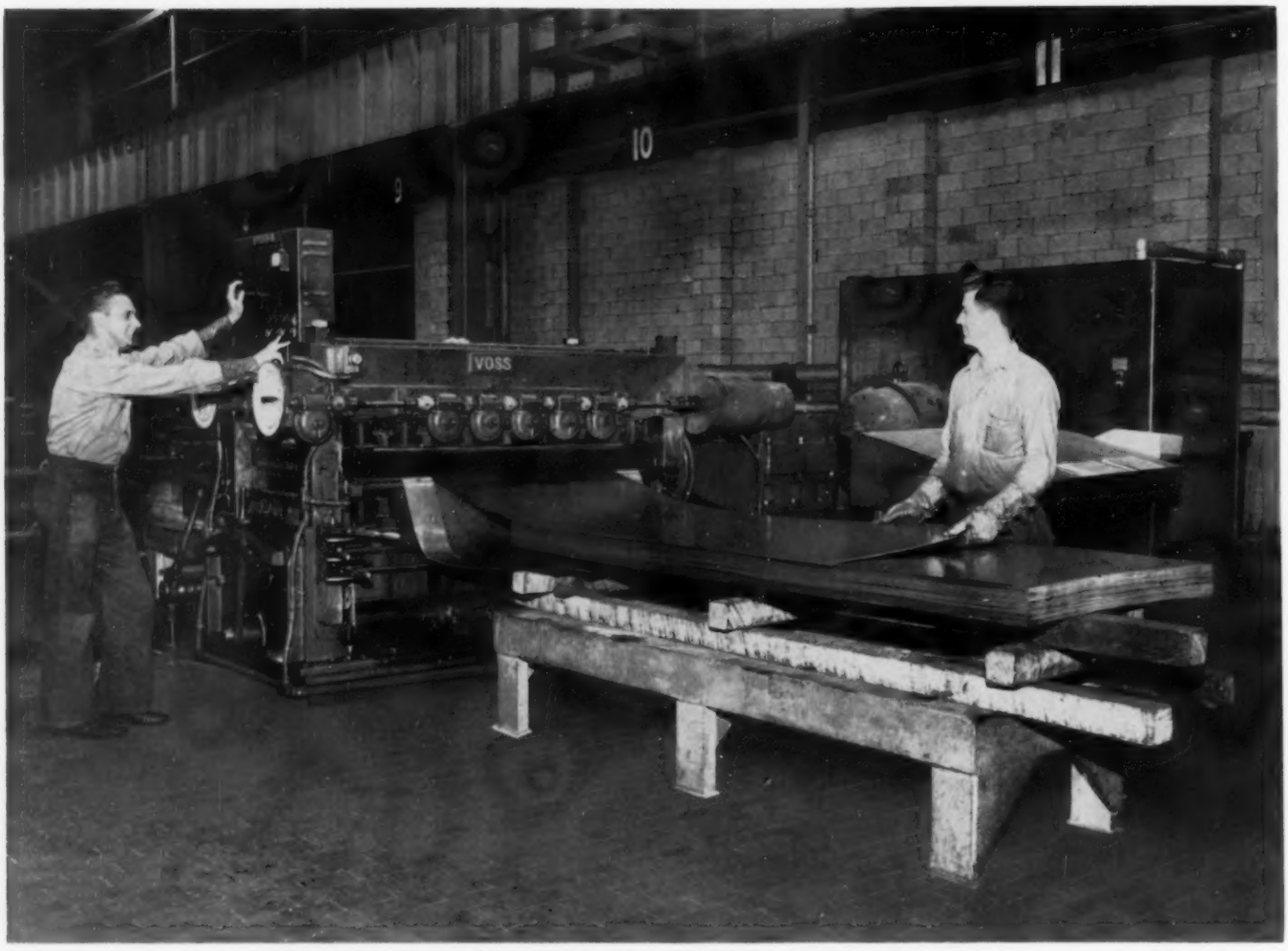

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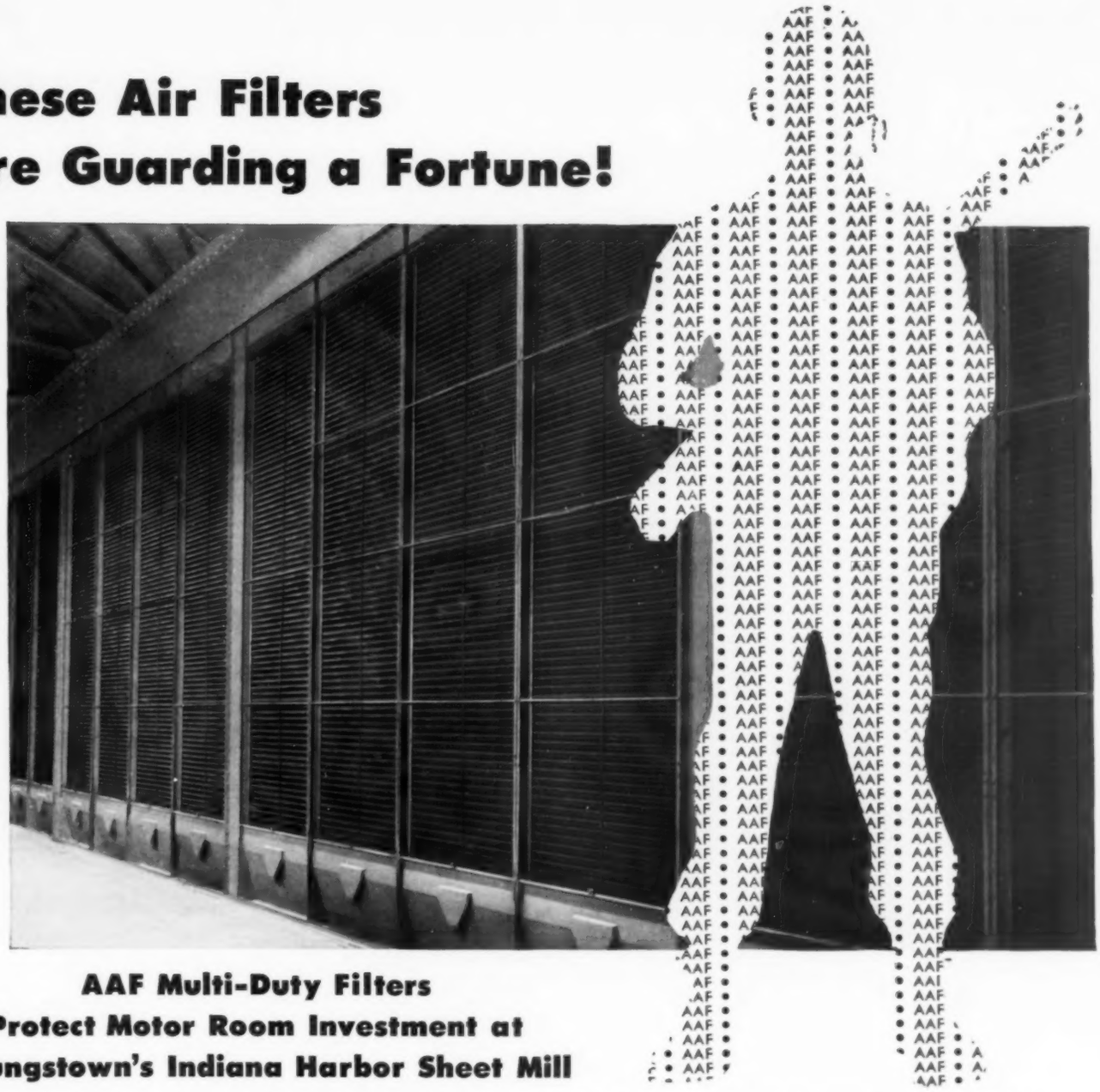
VOSS ENGINEERING CO.

7301 PENN AVENUE • PITTSBURGH 8, PA.

These Air Filters Are Guarding a Fortune!



AAF Multi-Duty Filters Protect Motor Room Investment at Youngstown's Indiana Harbor Sheet Mill

THE motor room serving the cold reduction mill at Youngstown Sheet and Tube Company houses a fortune in motors, generators and switch gear. Constant ventilation of this room is essential to prevent equipment from overheating—and the air must be clean. Dust and dirt provide a path for costly electrical losses; play havoc with coils and windings.

Pictured above is the "wall" of AAF Multi-Duty automatic air filters, totaling 533,000 cfm capacity, which supplies this vital protection. With these self-cleaning units standing guard, constant efficiency and uniform air cleaning are assured regardless of dust load. Multi-Dutys never punch a time clock. They're on the job every minute of the day; require no attention other than periodic inspection and removal of sludge.

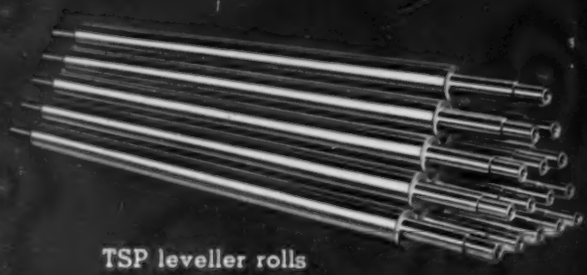
This is but one of scores of motor room "fortunes" over which Multi-Duty Filters are standing 24-hour guard. For complete product information, call your local AAF representative or write for Bulletin 241.

AAF

herman nelson

American Air Filter
COMPANY, INC.

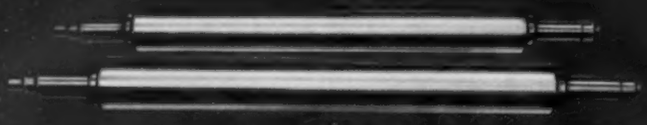
American Air Filter of Canada, Ltd., Montreal, P. Q. • 302 Central Avenue, Louisville 8, Kentucky



TSP leveller rolls

TSP shafts and axles on overhead cranes

TSP track wheels on overhead cranes

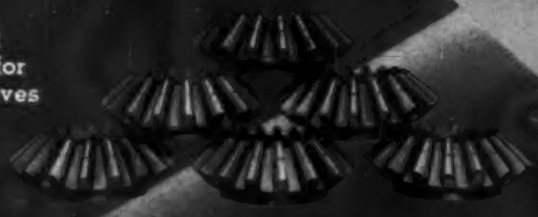


TSP pinch rolls

TSP HARDENED PRODUCTS

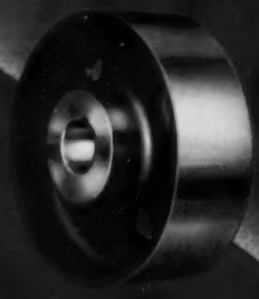
TSP skip car wheels in blast furnaces

TSP bevel gears for table drives



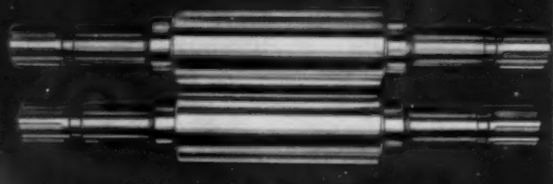
Illustrated here are a few of the hundreds of applications of "Tool Steel Process" hardened products now in use at The Youngstown Sheet and Tube Company.

TSP gearing on overhead cranes



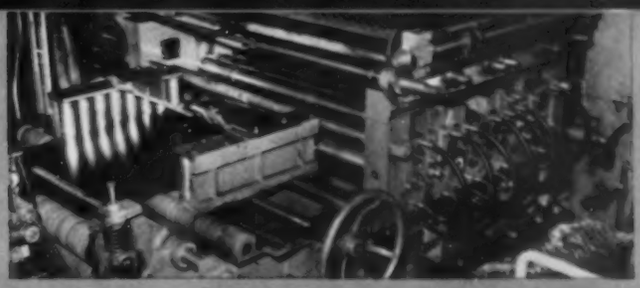
TSP brake wheels on overhead cranes

TSP sheave wheels on open hearth cranes



23" x 56" cold rolling rolls

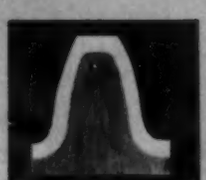
"Tool Steel Process" Hardened Products used at The Youngstown Sheet and Tube Company, Indiana Harbor Works, have established an enviable performance record through the years. Service records constantly prove that TSP hardened products last many times longer in the same service than competitive products, and this is backed up by Tool Steel's positive written guarantee on every TSP Product.



TSP rolls on McKay leveller in new shearing line

TSP rolls on straightener in merchant mills

. on the job since 1915 at YOUNGSTOWN SHEET AND TUBE CO.



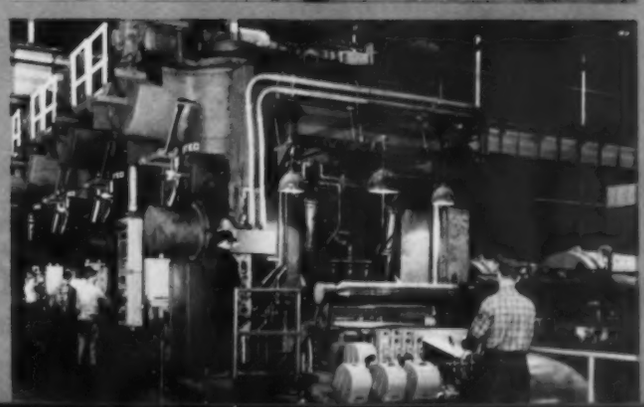
HERE'S WHY:

The tool steel wearing surface is especially hardened (85 to 100 sclerescope) to full depth of permissible wear. The low-carbon steel core is thoroughly refined through heat treatment (200 to 275 Brinell) to give the necessary strength and ductility to support the hardened surface. As an example, we illustrate a TSP gear tooth (cross section) designed for maximum resistance to surface wear, stress and fatigue. These superior qualities are found only in "Tool Steel Process" Hardened Products.

Our long experience in the Steel Industry, our special production facilities, metallurgy and engineering . . . all combine to make TSP products YOUR best investment. Comprehensive bulletins on TSP products and applications will be sent to you on request. Write today.

TSP products used on 46" United blooming and slabbing mill

TSP track wheels on Wellman floor charger in new open hearth



rolls on 56" United 4-high cold reduction mill

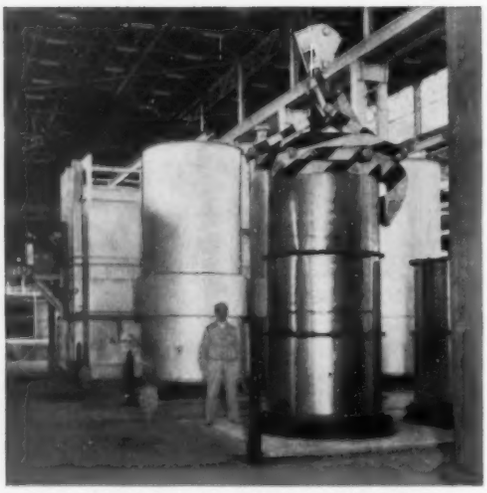
THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U.S.A.

The Standard of Quality since 1909
for Gears • Pinions • Rolls • Wheels
and other Hardened Products.

Ad No. 1016

Two large EF combination gas fired and electrically heated furnaces for uniformly annealing, normalizing, and galvanizing strip — continuously.

designed engineered and *Specially Built*



Part of an installation of large gas fired three-stack rectangular bell type forced circulation special atmosphere furnaces for annealing strip.

for continuous and batch processing of ferrous and non-ferrous strip

We are in position to design, build and put into operation: continuous or batch type equipment for hot or cold rolled, high or low carbon steel, stainless, silicon, tinplate, aluminum, brass, bronze or any other ferrous or non-ferrous metal — for bright annealing, normalizing, galvanizing, aluminizing, tinning or any other process — in the size and type best suited to your plant, process, product or production requirements. No job is too large or too unusual.

Put your production furnace problems up to experienced engineers—it pays.

THE ELECTRIC FURNACE CO.

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Salem - Ohio

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

This large EF combination electric and gas fired installation flame cleans, uniformly anneals and galvanizes strip continuously.

MEXICO REFRACTORIES CO.

NILES FIRE BRICK CO.
NATIONAL REFRACTORIES CO.

NAMES THAT MEAN OUTSTANDING QUALITY

Salute **The YOUNGSTOWN SHEET and TUBE Company**

INDIANA HARBOR WORKS

For many years MEX-R-CO "Better Refractories" have served the Indiana Harbor Works of The Youngstown Sheet and Tube Company, and we congratulate those men of vision who have been instrumental in the further expansion of production facilities, that the needs of an expanding group of customers be served. Such foresight is evidence of the progressiveness of its management, and confidence the company has in the future of this nation. We are proud to serve such a distinguished organization as The Youngstown Sheet and Tube Company

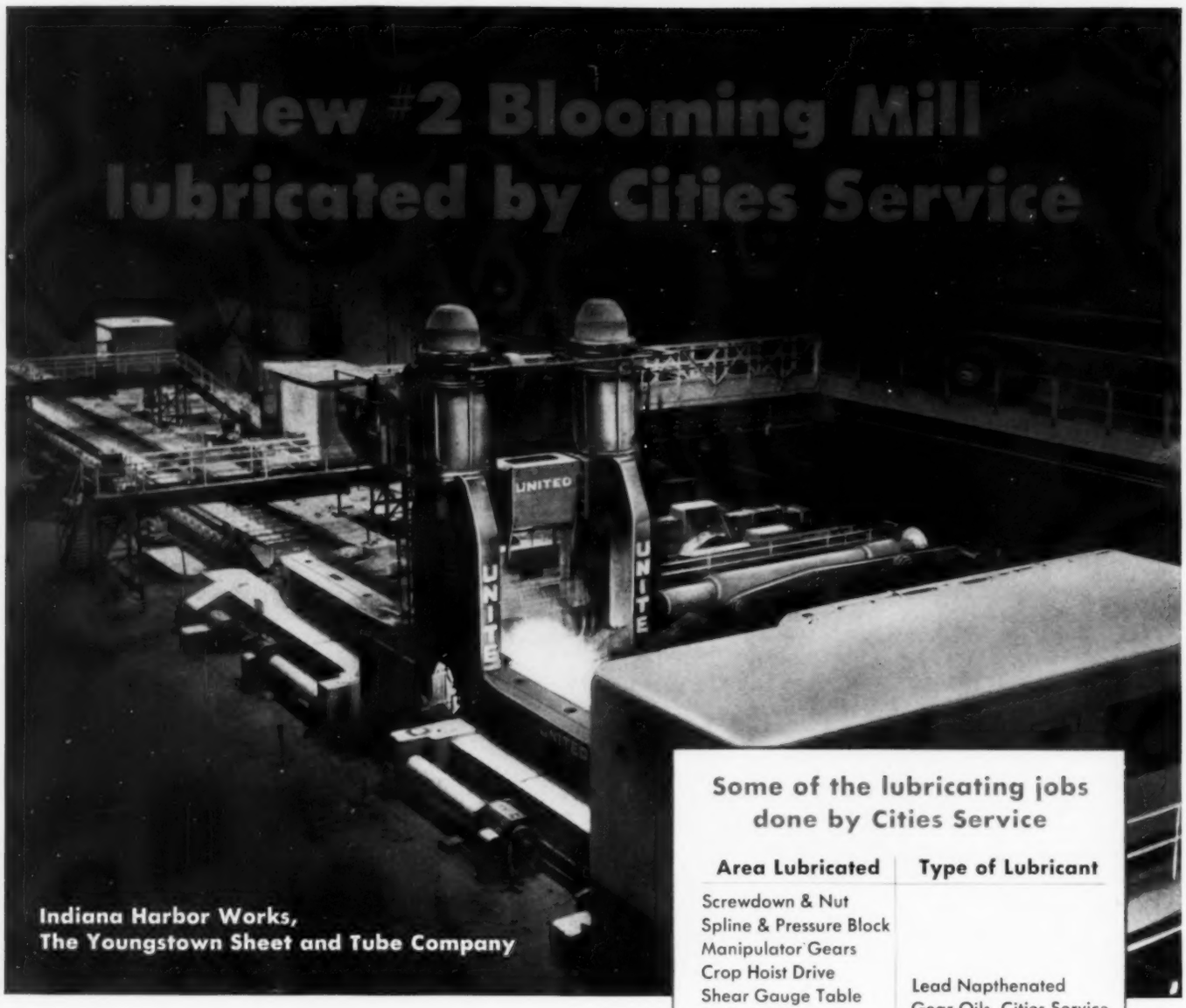
MEX-R-CO Super-duty and First Quality Missouri Fire-brick, Ladle Brick and Special Refractories meet the refractories requirements of The Youngstown Sheet and Tube Company.

MEXICO REFRACTORIES COMPANY, MEXICO, MISSOURI

NILES FIRE BRICK COMPANY, NILES, OHIO

NATIONAL REFRACTORIES COMPANY, PHILADELPHIA, PENN.

New #2 Blooming Mill lubricated by Cities Service



Indiana Harbor Works,
The Youngstown Sheet and Tube Company

Everywhere at the great Indiana Harbor Works of The Youngstown Sheet and Tube Company, the American genius for better machinery, better production methods is in abundant evidence.

Youngstown's new No. 2 Blooming Mill is a good example, consisting of the finest, most modern rolling-mill equipment in the steel industry . . . machinery designed to operate at far greater speeds for far longer periods.

Naturally, this also means far greater pressure . . . and calls for the finest extreme pressure lubricants . . . Cities Service Lubricants.

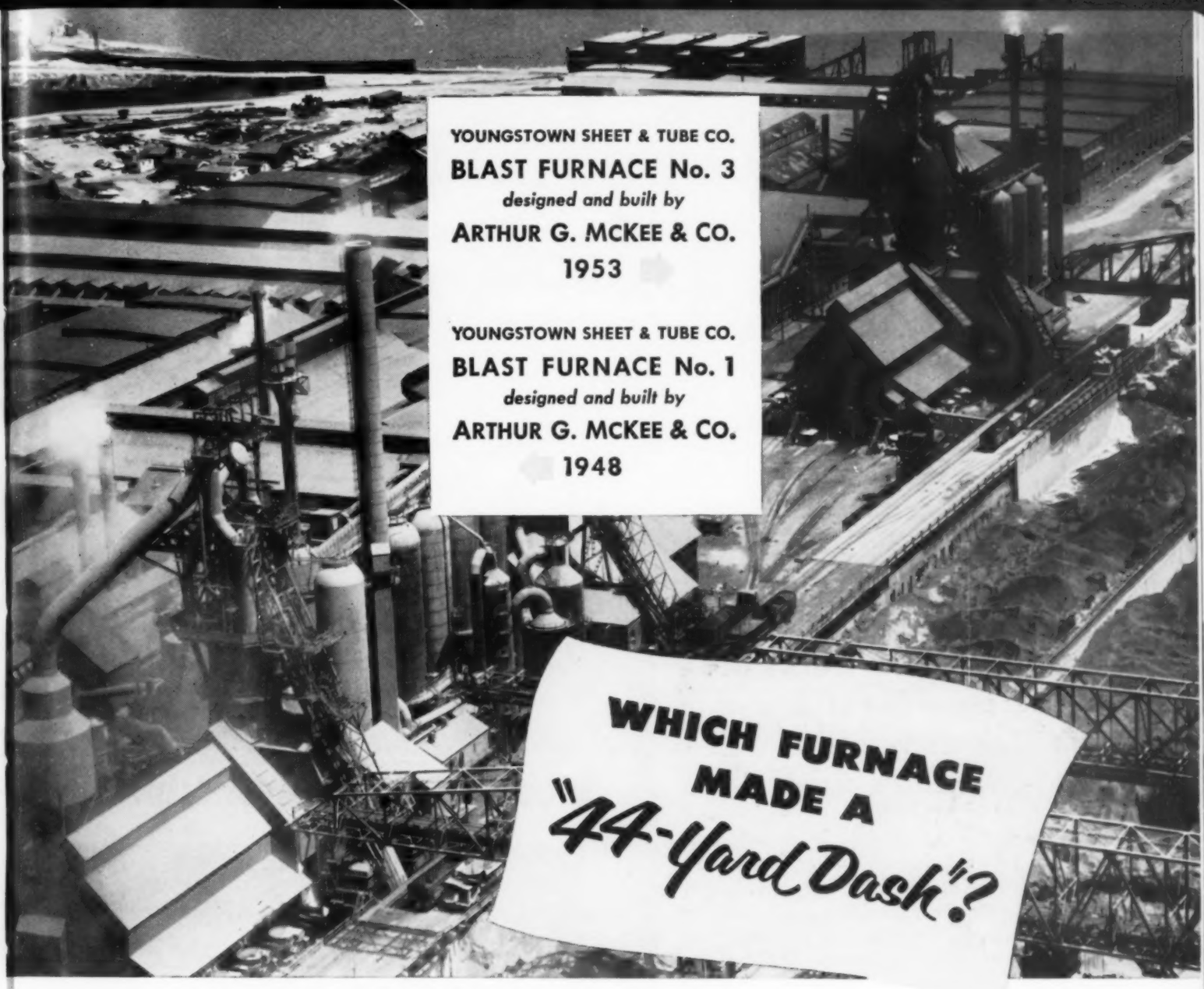
Used throughout the No. 2 Blooming Mill, these Cities Service Lubricants are now doing the same kind of outstanding job that's led to their exclusive use by so many American industries.

We thank you, Youngstown, for including Cities Service in your dynamic progress picture. We're proud that Cities Service Lubricants are part of your team . . . and we know you'll always be proud of their performance.

Some of the lubricating jobs done by Cities Service

Area Lubricated	Type of Lubricant
Screwdown & Nut Spline & Pressure Block Manipulator Gears Crop Hoist Drive Shear Gauge Table Scale Table Tilting Table on Shear Table Gear Drives Manipulator & Feed Roll Drives	Lead Napthenated Gear Oils, Cities Service Trojan L Compounds
All Centralized Lubricating Systems	Heavy Duty Steel Mill Grease, Cities Service Trojan EP Greases
All Motor Bearings and Overhead Crane Applications	Cities Service Trojan M Greases
Hydraulic Systems Air Line Lubricators Gear Reduction Units Motor Generator Set Pedestal Bearings Main Mill Drive Motors	Cities Service Pacemaker Oils
All Worm Gears	Cities Service Optimus #6

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS


YOUNGSTOWN SHEET & TUBE CO.
BLAST FURNACE No. 3
designed and built by
ARTHUR G. McKEE & CO.
1953
YOUNGSTOWN SHEET & TUBE CO.
BLAST FURNACE No. 1
designed and built by
ARTHUR G. McKEE & CO.
1948
WHICH FURNACE MADE A "44-Yard Dash"?

IN 1948, during a period of peak demand, McKee designed and built the new Youngstown Sheet & Tube No. 1 Furnace on a temporary foundation, 131 feet 6 inches from its present site.

While the original No. 1 stack was still in blast McKee engineers erected the furnace shell, offtakes and uptakes, and top structure on a temporary structural steel foundation. With the plate work almost completed, the old furnace was blown out and dismantled and a new foundation built. The new No. 1 Furnace then made its "44-yard dash," across a specially-constructed platform, to the permanent location. The unique engineering project was completed 27 days ahead of schedule and elapsed time from iron to iron was only 97 days.

The new, 28-foot-hearth-diameter Youngstown No. 3 Furnace, designed and built by McKee, was blown in early in 1953.

Both of these furnaces, from their foundations up, are products of the meticulous engineering and experienced construction methods provided by the McKee organization.

50th ANNIVERSARY

McKee Engineering Services

Arthur G. McKee & Company • Engineers and Contractors

Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

Walsh Products Installed in Indiana Harbor Works of Youngstown Sheet & Tube Company

Walsh takes justifiable pride in the fact that a variety of its products have been installed and are presently serving in maintenance capacity in the Indiana Harber plant of the Youngstown Sheet and Tube Company. Walsh Missouri-Quality Refractories have helped to bring efficiency and ecomomy to steel companies throughout the country. Each time-tested brand of Walsh fire brick or other refractory material is an investment in greater production . . . lower cost . . . the result of careful selection of raw materials, advanced methods of manufacture and better research and ceramic engineering. We are anxious to demonstrate the dependability of Walsh Refractories in your operation. Your inquiries are welcome and will have our prompt attention.

MULLITEX Super Duty Fire Brick • Hi Lumite brands of fire brick—50%, 60% and 70% alumina content • Walsh Insulating and Refractary Castables • High Temperature Cements • Plastic Fire Brick • Other Higher Temperatures and Special Ramming Mixes.

Six Great Names in Steel Industry Refractories

WARCO XX—High Heat Duty Fire Brick. Dry press Process, Tunnel Kiln Burned.

WR LADLE BRICK—High Refractory, Low Porosity. Dry Press Process, Tunnel Kiln Burned.

MORT-AIRSET—Air Setting high temperature bonding mortar.

MULLITEX HB Super Duty High Burn Fire Brick, Dry Press Process, Tunnel Kiln Burned. 100% Missouri Clays.

APEX—Extra Duty Stiff Mud Deaired Highest Bulk Density Fire Brick.

METALOK—metal and slag resistant heatsetting mortar.

CSR BURNER BLOCKS

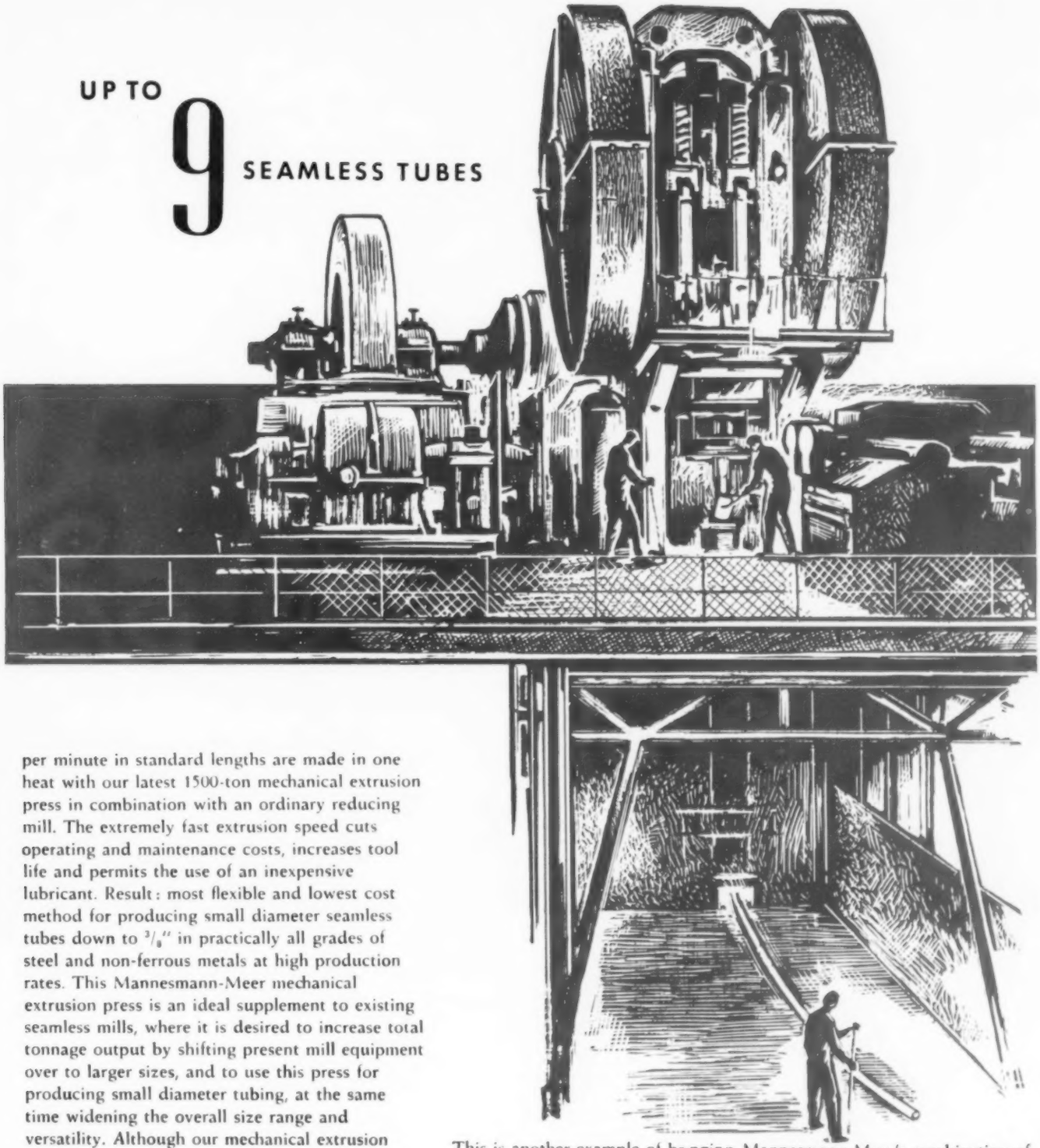
WALSH

REFRACTORIES CORPORATION

101 Ferry Street • St. Louis 7, Missouri

For over 60 years manufacturers of high grade refractories

UP TO **9** SEAMLESS TUBES



per minute in standard lengths are made in one heat with our latest 1500-ton mechanical extrusion press in combination with an ordinary reducing mill. The extremely fast extrusion speed cuts operating and maintenance costs, increases tool life and permits the use of an inexpensive lubricant. Result: most flexible and lowest cost method for producing small diameter seamless tubes down to $^3/_8$" in practically all grades of steel and non-ferrous metals at high production rates. This Mannesmann-Meer mechanical extrusion press is an ideal supplement to existing seamless mills, where it is desired to increase total tonnage output by shifting present mill equipment over to larger sizes, and to use this press for producing small diameter tubing, at the same time widening the overall size range and versatility. Although our mechanical extrusion presses are in operation for over 25 years, continuous development is incorporated in today's press design to match present and future operating requirements.

This is another example of bringing Mannesmann-Meer's combination of

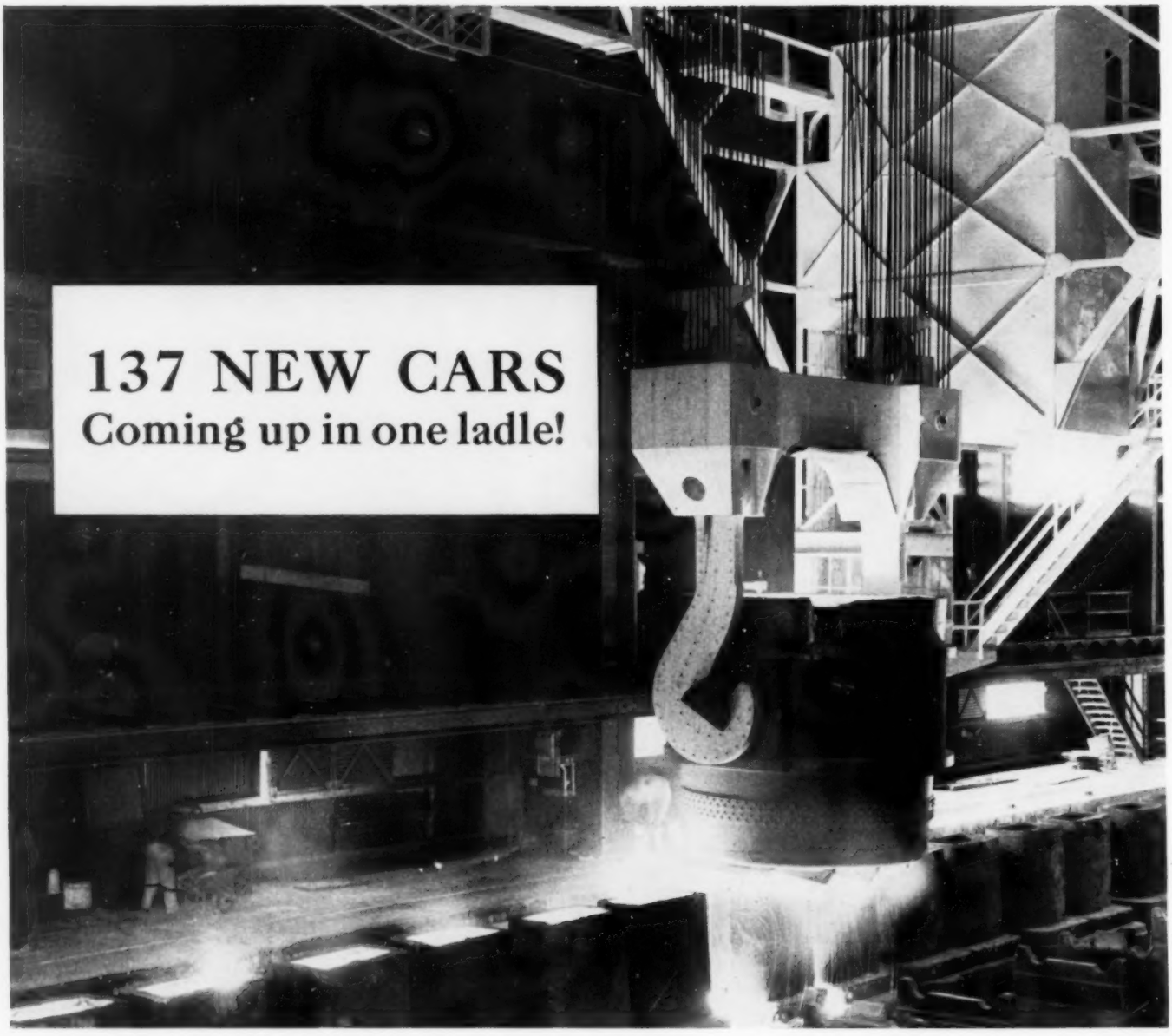
- CREATIVE ENGINEERING
- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

to bear on your tube mill problems.

MANNESMANN-MEER

ENGINEERING AND CONSTRUCTION COMPANY, 900 LINE STREET, EASTON, PENNA

WORLD SPECIALISTS IN HIGH-SPEED TUBE MILL MACHINERY



THAT'S right! There are 275 tons of steel in this pouring ladle, enough to build 137 new cars. You'll find Yellow Strand, Flattened Strand, 6 x 30, Style G, IWRC Wire Rope carrying this weight from one ingot mold to another for Youngstown Sheet & Tube Co. at their Indiana plant, Indiana Harbor. Tough Yellow Strand stands up to the high ambient heat and supports the combined total weight of 350 ton ladle and steel with ease.

If you have a problem spot for wire rope, where sheaves, drums or the rope itself is wearing too fast, solve it with Yellow Strand Flattened Strand! Yellow Strand Flattened Strand is formed of strands laid up in a triangular form to obtain a smoother outer surface.

You get 10% greater metallic area, a corresponding increase in strength, plus a compactness unobtainable in round strand construction. It is not uncommon to get twice the service — and even more! This means you also save much of the time lost in frequent rope changes. Call your Broderick & Bascom distributor today or write us direct.

BRODERICK & BASCOM ROPE CO.
4203 Union Blvd. St. Louis 15, Mo.

SPECIFY...
Yellow Strand
For Savings...Safety
...Speedi-Service

INSTALLATION ENGINEERING

- FOUNDATIONS
- ELECTRICAL
- STRUCTURAL
- PIPING
- ESTIMATING
- COST CONTROL

PROJECTS ENGINEERED

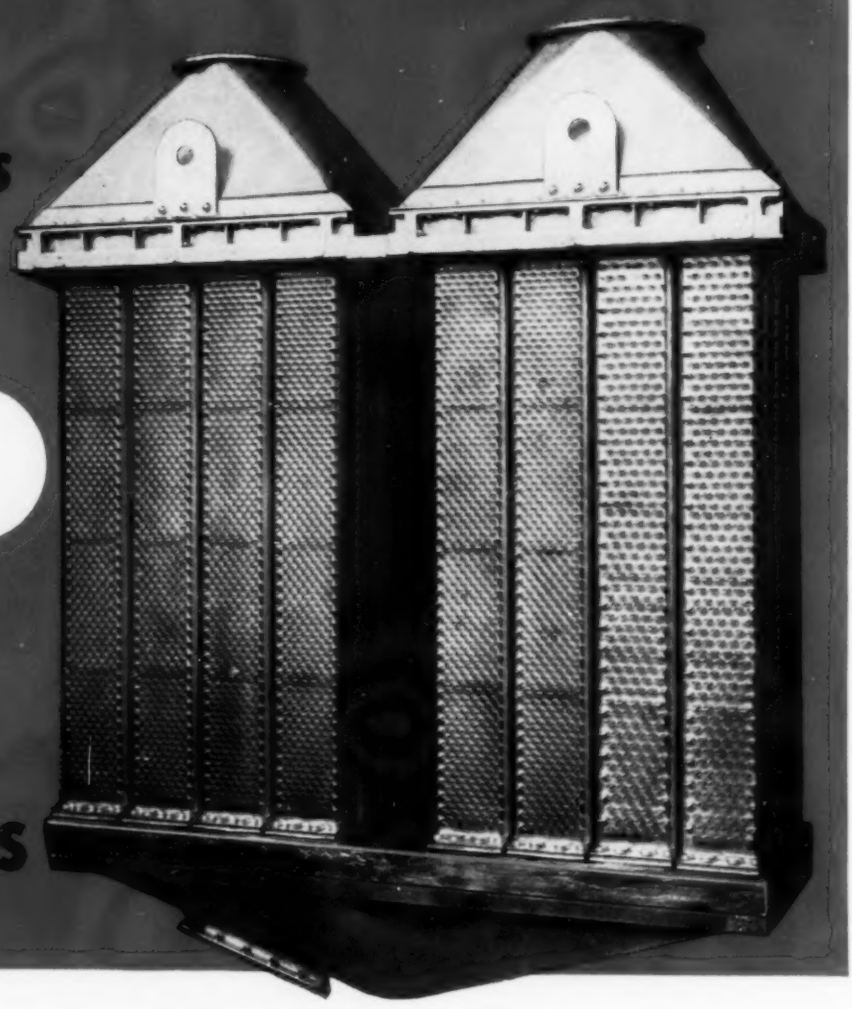
For YOUNGSTOWN SHEET & TUBE CO.
(INDIANA HARBOR WORKS)

No. 2 Continuous Butt Weld Mill - - - - - - - - - - - (Electrical)
10" Skelp Mill - (Electrical)
12500 K V A Turbo Generator - - - - - (Fdn.,-Piping,-Electrical)
125,000 CFM Turbo Blower - - - - - - - (Fdn.,-Piping,-Electrical)
No. 5 Boiler "Boiler House" - - - - - - (Fdn.,-Piping,-Electrical)
Cold Reduction Mills - - - - - - - - - - - - - - - (Fdn.,-Electrical)
Tinning Mills — Now in Progress - - - - - - - (Prime Engineers)
Seamless Mill — Now in Progress - - - - - - - (Prime Engineers)

FROM ELECTRICAL TO PRIME INDICATES A GROWING CONFIDENCE IN OUR SERVICES WHICH IS TYPICAL OF THE STEEL INDUSTRY

AUBURN & ASSOCIATES, INC.
Engineers
PITTSBURGH 22, PENNA.
SPECIALISTS IN STEEL MILL ENGINEERING

Cut Your Heating Costs With TTC



Needle-type Metallic Recuperators

TTC Needle-type Metallic Recuperators guarantee substantial fuel economies. Years of experience in the plants of the nation's leading steel producers and fabricators offer time-proven performance. Flexibility of application and long, trouble-free service-life assure TTC recuperator efficiency. The design eliminates leakage and minimizes pressure and draft loss.

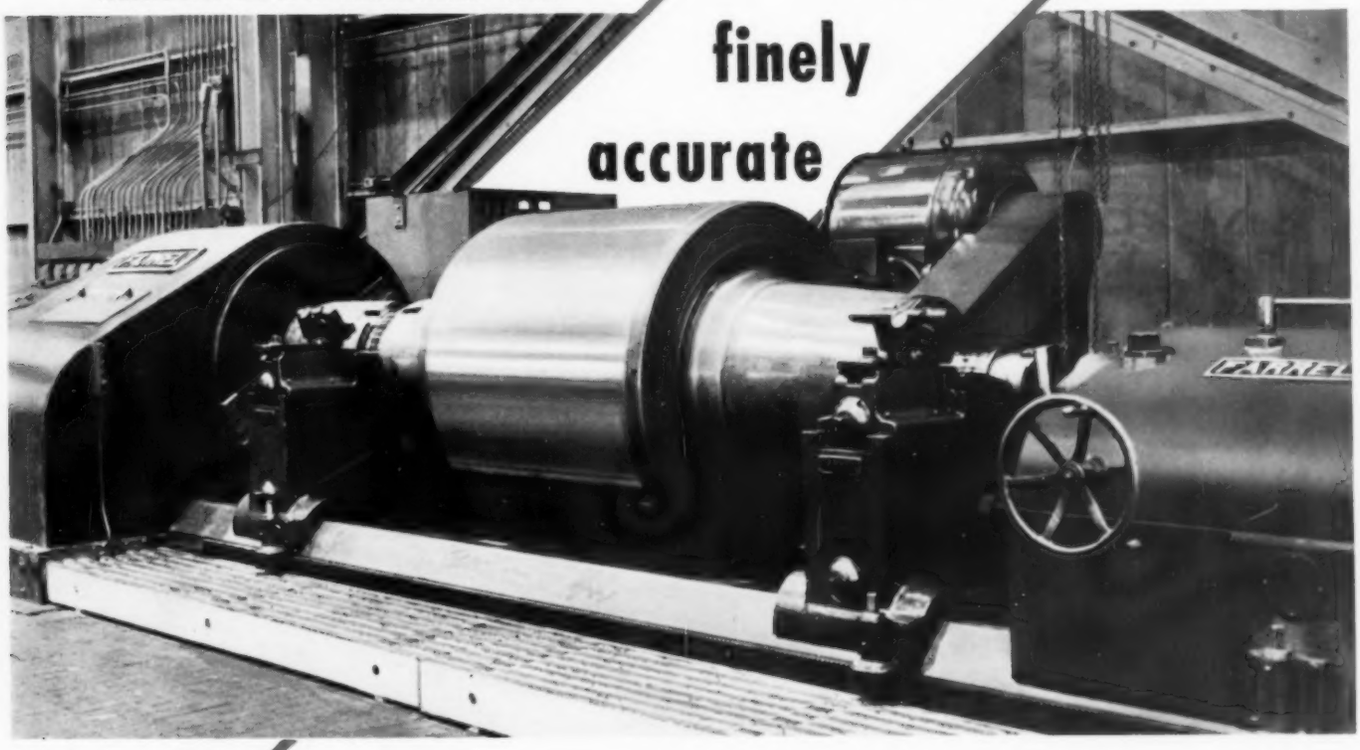
Write or phone for a TTC recommendation to help reduce your heating costs.

Thermal Transfer Corporation

Investment Building • Pittsburgh 22, Pa. • ATlantic 1-0437

Roll grinding at Youngstown Sheet and Tube is both fast and finely accurate

One of two 60" X 16'0" Farrel heavy duty roll grinders in Youngstown Sheet and Tube's cold reduced sheet mill at the Indiana Harbor Works.



WITH two Farrel® heavy duty roll grinders at the Indiana Harbor Works, Youngstown Sheet and Tube Company has been able to evaluate the performance of these machines.

They find that the Farrel machines will grind straight, convex or concave contours to exact symmetry and accuracy . . . without marks of any kind . . . in minimum time. In addition, experience has shown that these grinders are easy to handle, both in setup and operation.

Contributing to grinding accuracy is the Farrel automatic crowning and concaving device. Easily and quickly set, it requires no manipulation during operation. The same setting produces exactly the same curvature and permits fixed, uniform and easily controlled accuracy of contour in all rolls.

Farrel heavy duty roll grinders are designed to take heavy cuts for rough grinding and to grind rolls to the highest mirror finish. They are made in six sizes for maximum roll diameters of 24", 28", 36", 44", 50" and 60", any length required.

If you would like to reduce grinding time and cost, and refinish your rolls more accurately, look into Farrel grinders. Send for detailed information.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

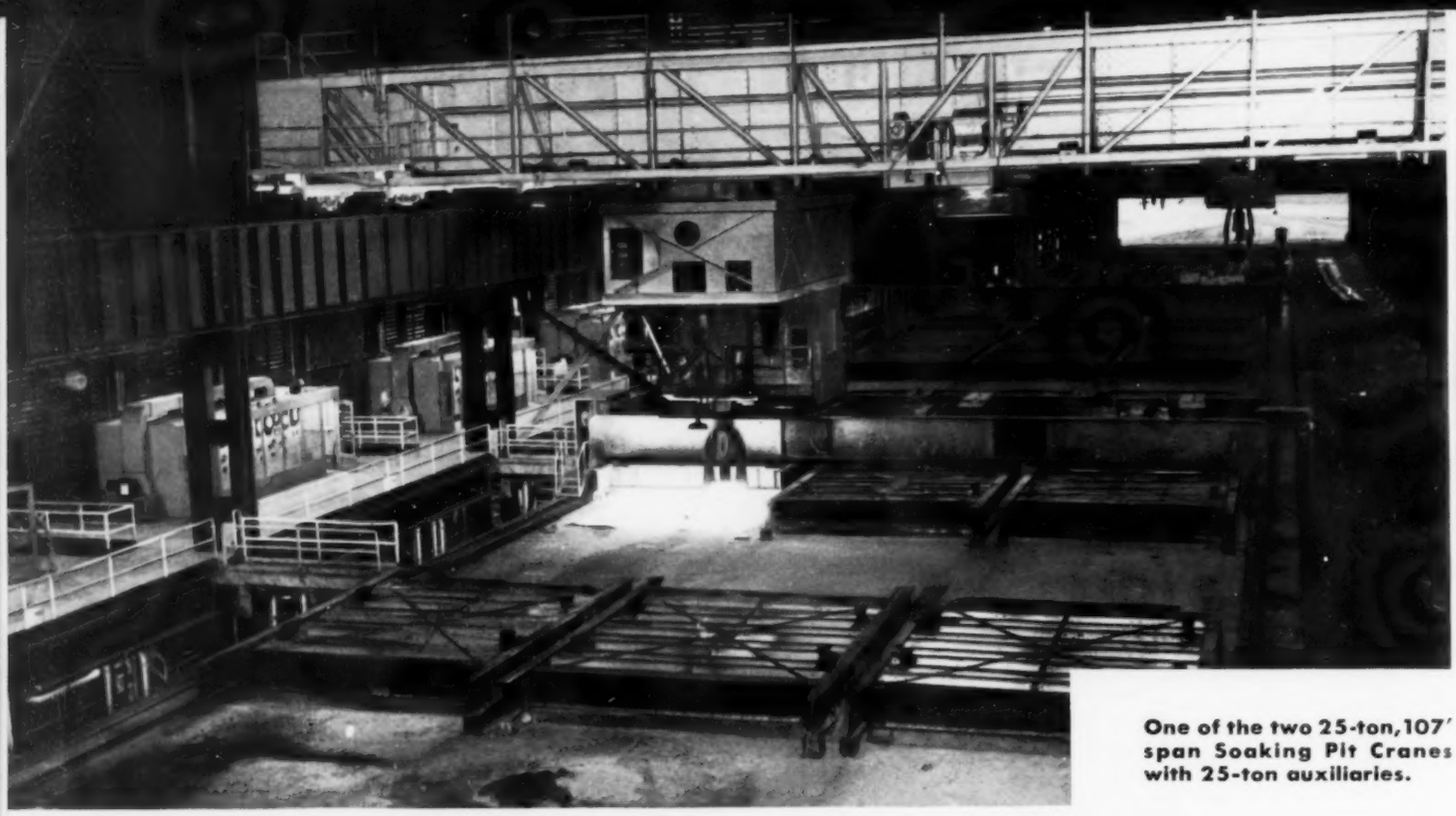
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Pittsburgh, Chicago, Fayetteville (N. C.), Los Angeles, Houston

FB-1031

FARREL ROLLING MILL MACHINERY

Rolls • Rolling Mills • Rod Mill Tables and Manipulating Equipment • Universal Mill Spindles • Rod Coilers • Gears • Mill Pinions • Pinion Stands • Gear Drives of Any Capacity • Flexible Couplings • Roll Grinding Machines • Roll Calipers.

Farrel-Birmingham®



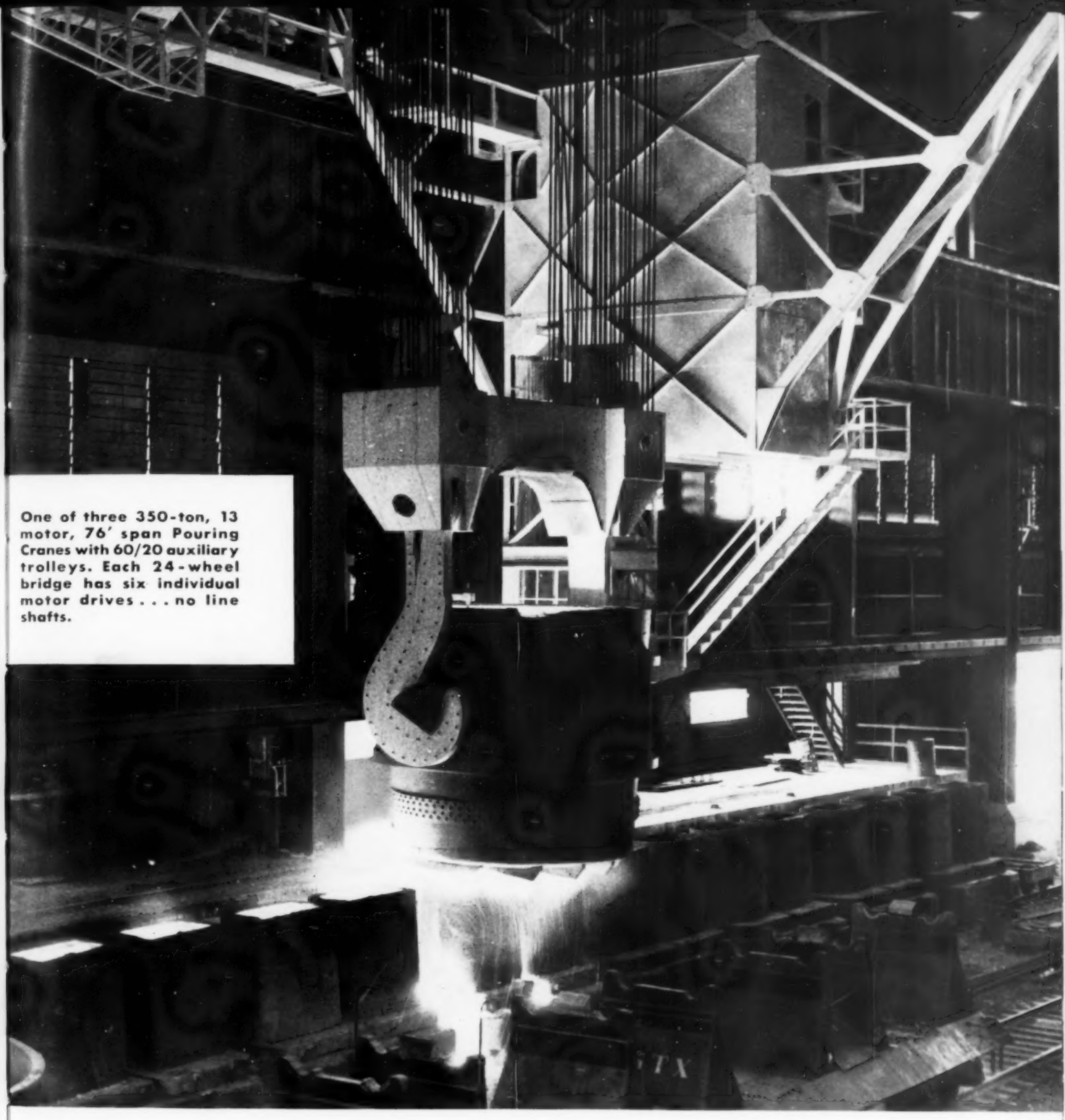
One of the two 25-ton, 107′ span Soaking Pit Cranes with 25-ton auxiliaries.

One of three 12-ton, 27′ span O. H. Chargers.

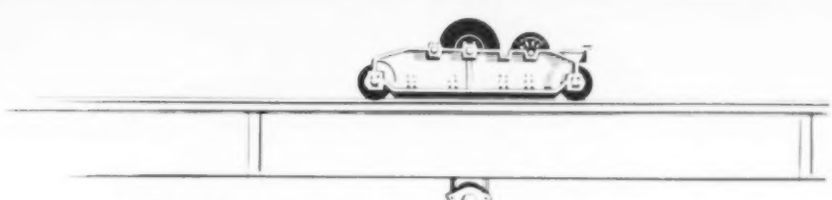
Youngstown uses Morgan equipment in new Indiana Harbor Plant

● The advanced design and quality construction of Morgan cranes and chargers assure long-term economies in the operation of the new Youngstown Sheet and Tube Plant at Indiana Harbor.

Performance records prove Morgan equipment is economical to operate and maintain.

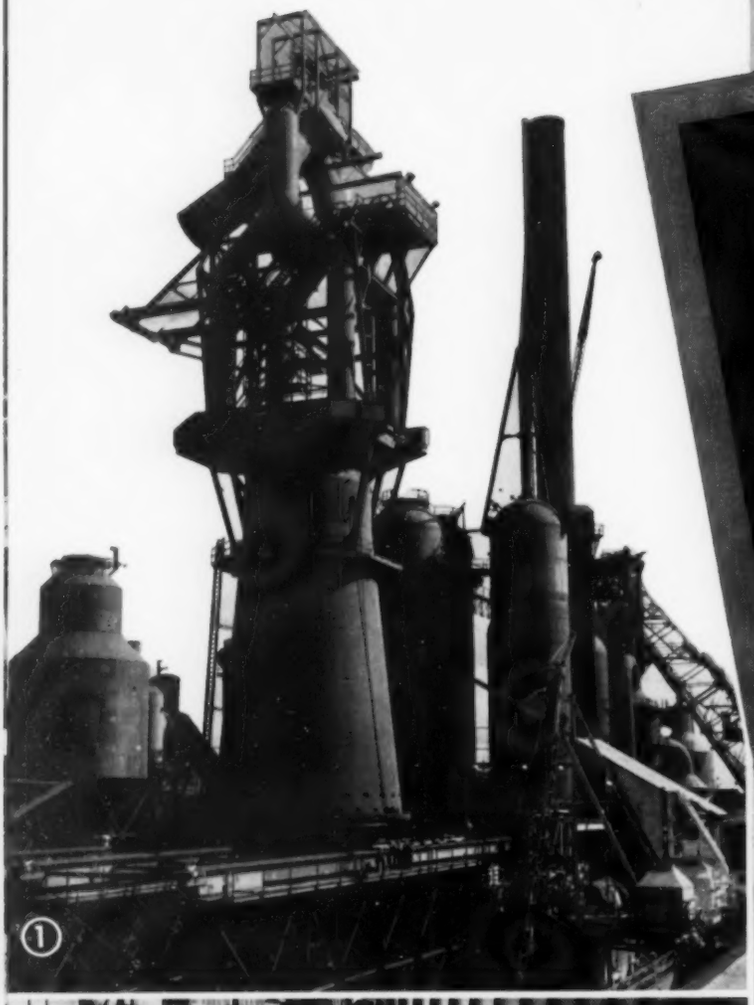


One of three 350-ton, 13 motor, 76′ span Pouring Cranes with 60/20 auxiliary trolleys. Each 24-wheel bridge has six individual motor drives . . . no line shafts.

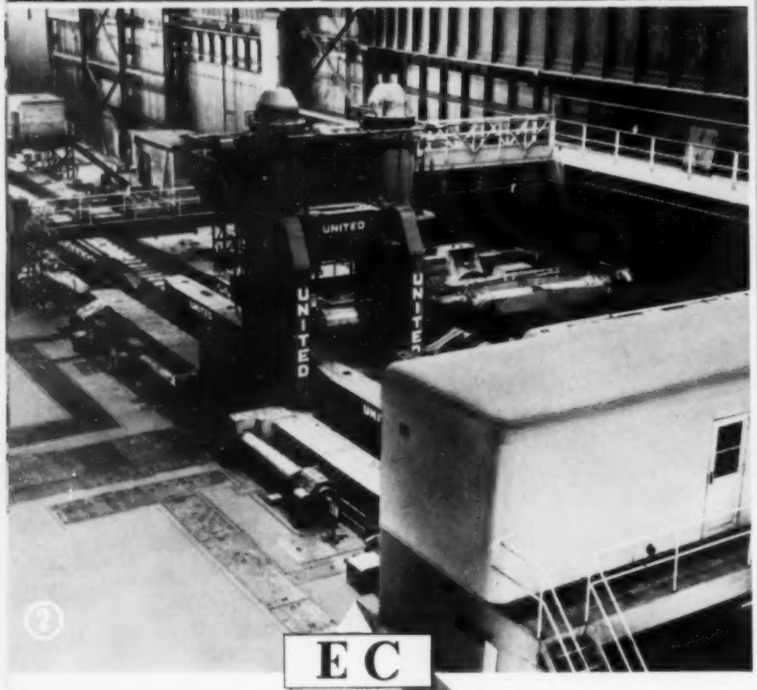


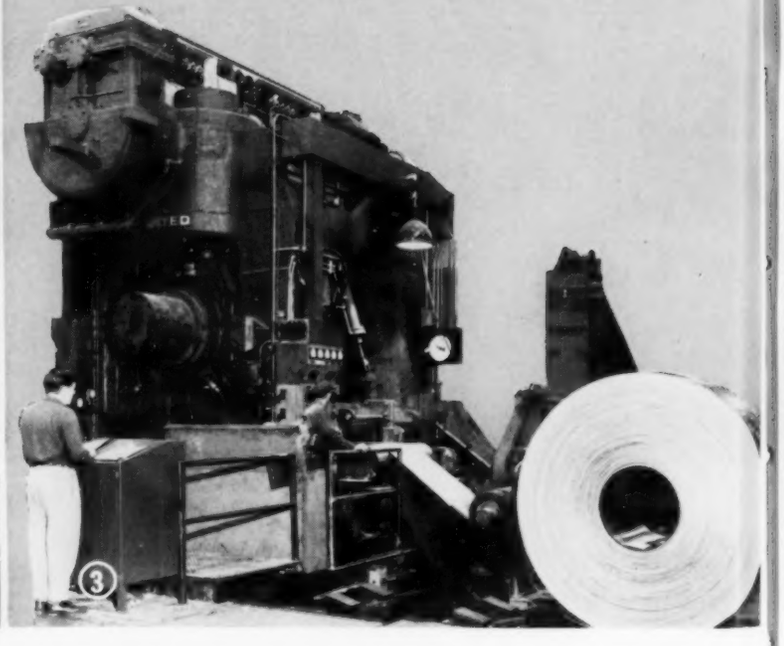
The Morgan Engineering Company manufactures overhead electric traveling cranes, gantry cranes, charging machines, plate mills, blooming mills, structural mills, shears and saws.

THE MORGAN ENGINEERING CO. *Alliance, Ohio*



Expanded Facilities for Expanded Service at YOUNGSTOWN SHEET and TUBE COMPANY





EC

INSTALLATION ENGINEERING

VERSATILITY SPEED ECONOMY

ABILITY EXPERIENCE ACCURACY

Eichleay

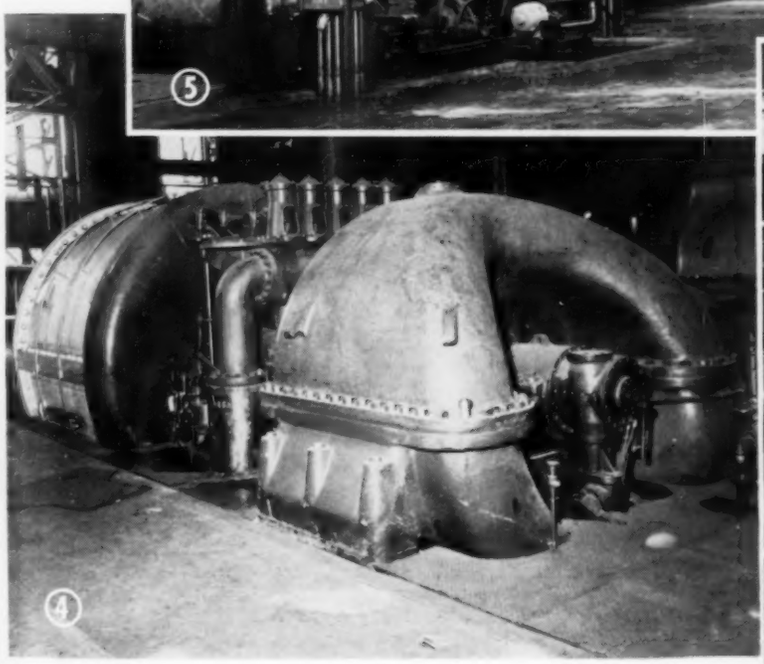
ESTABLISHED 1875

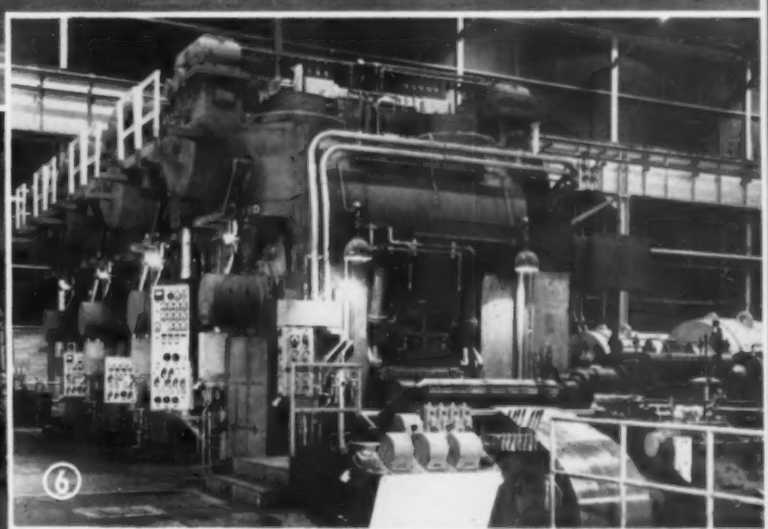
Mechanical Erection by Eichleay

1. Blast Furnace being moved to location. Furnace was built off-site to utilize full operating time of existing operating unit due for replacement.
2. Complete mechanical installation of the Two-High Reversing Blooming Mill and auxiliaries.
3. Complete mechanical installation of the 56″ Four-High Skin Pass Mill.
4. Complete mechanical installation of a 125,000 C.F.M. Turbo Blower including all auxiliary equipment.
5. Complete mechanical installation of the 60″ Continuous Pickle Line.
6. Complete mechanical installation of the 56″ Four-Stand Tandem Cold Strip Mill.
7. Installation of foundations and structural steel supports for two 125,000 C.F.M. Turbo Blowers.

EICHLEAY SERVICES

Industrial Installations
Construction of Heavy Foundations
Building and Machinery Moving
Shoring — Rigging

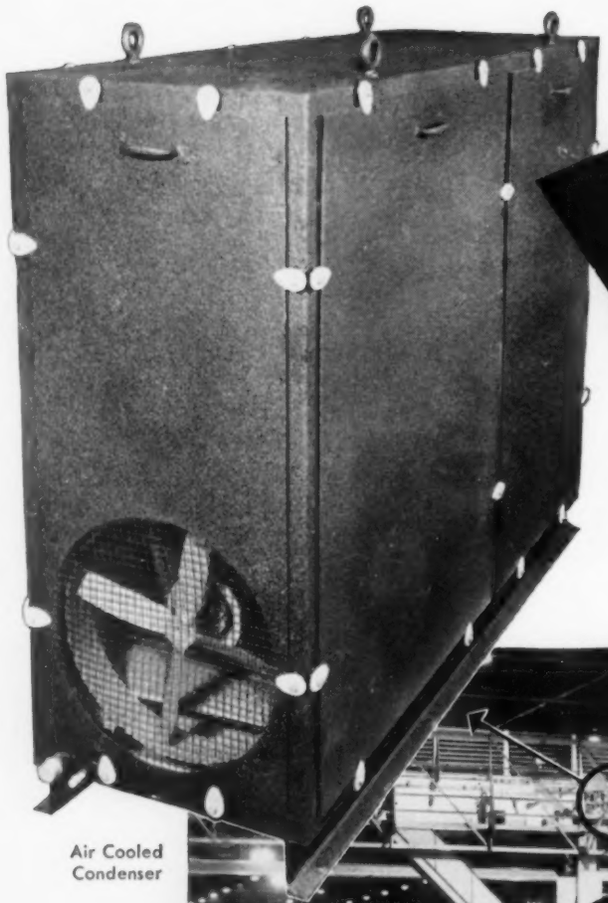




CORPORATION

33 South 19th St., Pittsburgh 3, Pa.

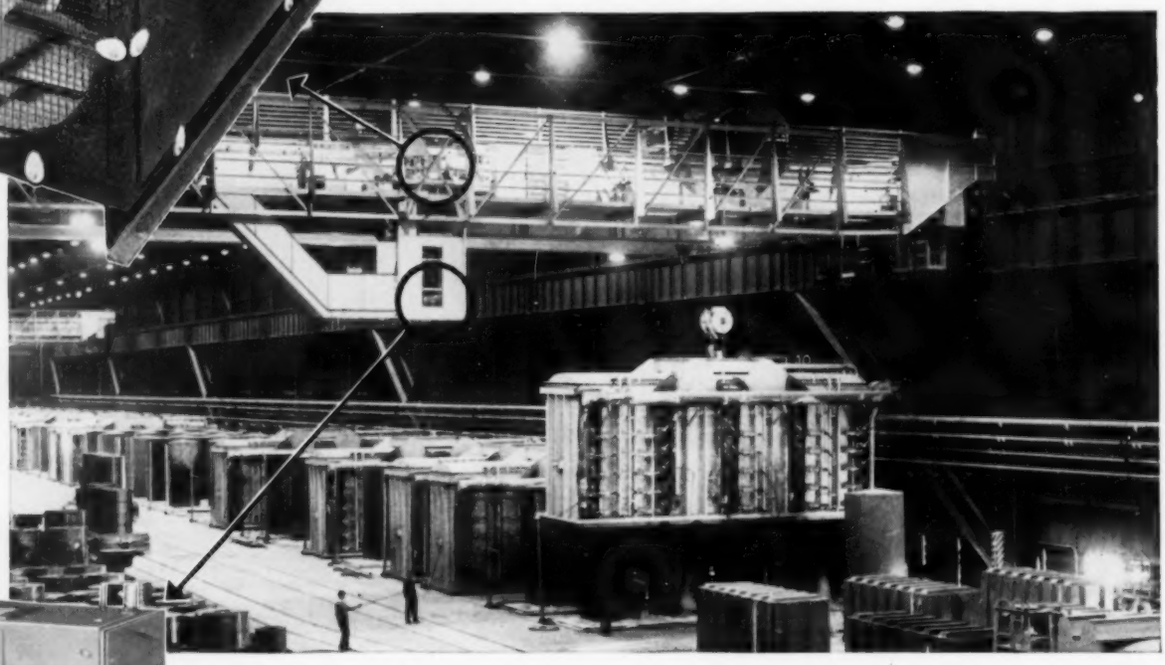
681 Market St., San Francisco 5, Calif.



LINTERN ENGINEERING at work

THE YOUNGSTOWN SHEET AND TUBE COMPANY
(INDIANA HARBOR)

Air Cooled Condenser



Cooling Unit—floor type—located in cab. Condenser and Cooling Unit are connected by refrigerant lines resulting in efficient operation although the units are widely separated.

The Youngstown Sheet and Tube Co. installed their first Lintern Aire-Rectifier five years ago. Since then they have made additional installations on cranes where excessive heat required improvement of working conditions.

Illustrated is a recent installation on an annealing department crane at the cold reduction sheet mill. It is the model 527 AC-7.5 Aire-Rectifier with floor type cab unit.

In all major steel plants, peak production naturally follows installation of the pioneer product in the field — Lintern Aire-Rectifiers.

THE LINTERN CORPORATION
ROUTE 20 EAST • PAINESVILLE, OHIO
BIRMINGHAM • DETROIT • PITTSBURGH • CHICAGO
PHILADELPHIA • SAN FRANCISCO • ST. LOUIS • DENVER

STOVE CLEANED IN TWO DAYS

DOWELL chemical cleaning increased time stove could be kept on furnace by 66%

The operator of this blast furnace stove had a problem. One like it may face you. He knew the modern solution. Do you?

His problem: From 14 to 19 feet of brick spalls and flue dust had accumulated on top of the ball inserts in the checkers, cutting time on the furnace drastically. He had to increase that time, yet he didn't want to take the stove out of operation for the long period required by mechanical cleaning.

His solution: He called Dowell engineers to clean the checkers chemically. Using special headers, they washed the flues with solvents in just 2½ hours. After overnight soaking, all 1,000 checkers were jetted in 5 hours with high-pressure water. Plugging materials were disintegrated. Total cleaning time—two days.

His results: After Dowell cleaning, the stove could hold 1200°F. for more than 2½ hours on the furnace . . . compared to 950°F. for only 1½ hours before. Efficiency was restored at minimum expense, in minimum downtime.

A regular schedule of Dowell chemical cleaning in *your* plant may pay for itself many times over . . . in greater production efficiency, longer equipment life, less outage time, lower maintenance cost. Find out! Call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Department I-29.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

POLLOCK'S *Economic Impact in the Steel Industry*

Ever since Pollock designed and built the first steel plate blast furnace shells to replace the early stone shells, Pollock ingenuity and equipment have increased efficiency and reduced costs in steel plants throughout the world.

The modern installations pictured here were furnished by Pollock for the new Youngstown Sheet & Tube Company blast furnace and open hearth at Indiana Harbor.

They are typical of the giant accomplishments steelmakers everywhere expect of The William B. Pollock Company . . . specialists in all construction matters pertaining to the manufacture of iron and steel.

Front-flush Slag Car

400-Cu. Ft., O. H. Slag Cars

215-Ton Welded O. H. Ladle

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN OHIO

STEEL PLATE CONSTRUCTION
ENGINEERS · FABRICATORS · ERECTORS

Established 1863

Since 1926

CLEVELAND WORM GEAR DRIVES

have been serving at Youngstown's Indiana Harbor Works

MORE than 600 Cleveland Worm Gear Speed Reducers and drives of built-in worm gearing are in service at the Indiana Harbor Works of The Youngstown Sheet and Tube Company in East Chicago, Indiana. Many of these units have been operating steadily for 25 to 30 years.

Here, as at the other mills of Youngstown, Clevelands are serving dependably in a wide variety of applications. They demand a minimum of attention and maintenance.

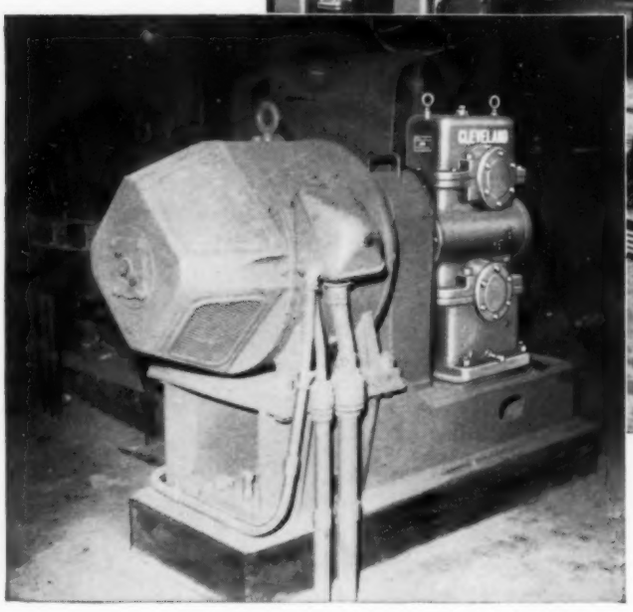
The satisfactory experience of Youngstown engineers with Clevelands is duplicated in hundreds of other plants in the steel and metal working industries.

Cleveland Worm and Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication.
In Canada: Peacock Brothers Limited.

At right—Drives for rolling pipe to clean in pickling tanks before galvanizing at No. 1 and 2 galvanizing units at pipe mills.

Below—Needle feed roll drive to entry end of No. 2 continuous weld pipe mill heating furnace.



CLEVELAND
Worm Gear
Speed Reducers

FARVAL at Indiana Harbor Works

lubricates 1278 bearings in Sheet Mill . . . protects thousands of others throughout Youngstown plant

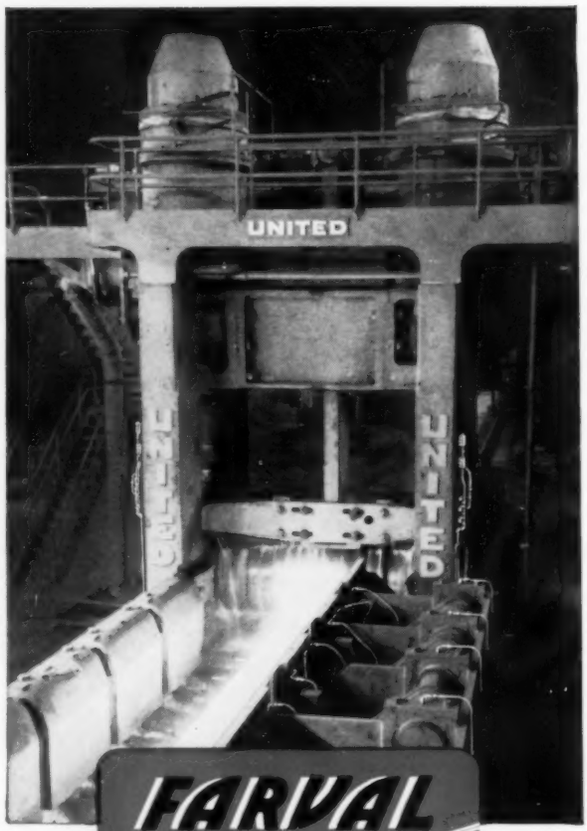
SINCE its first Farval system was put on a 200-ton ladle crane back in 1930, Youngstown has installed more than 200 systems, manual and automatic, on the equipment at its Indiana Harbor Works, from blast furnaces to loading-out cranes. All told, more than 8,900 bearings are *Farval-lubricated.*

The latest major installation of Farval centralized lubrication was in the recently completed sheet mill, where 1,278 bearings are served on the 4-high 4-stand continuous cold-reduction mill, temper mill, shears, pickling line and other accessory equipment.

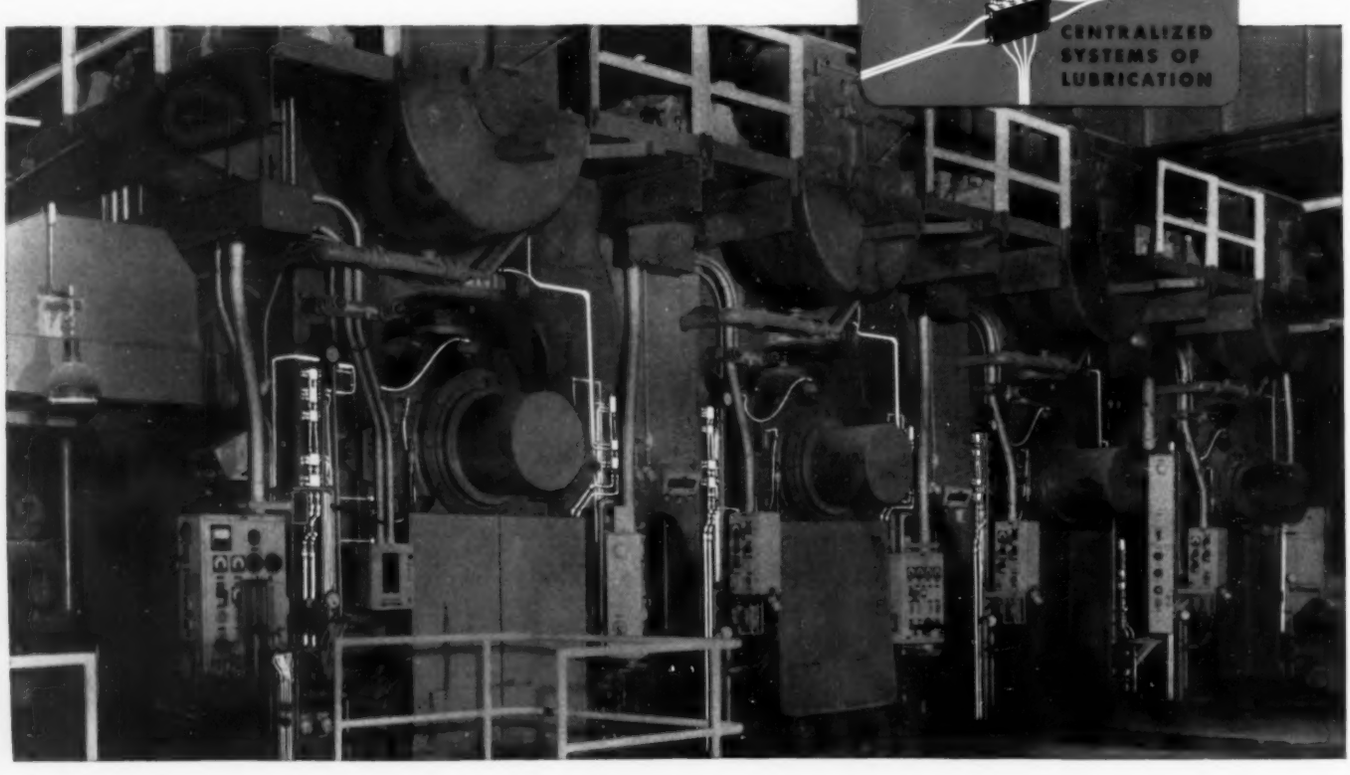
Lubrication engineers and other maintenance personnel are well acquainted with the valuable savings made possible by Farval—savings in bearing replacement expense, savings in downtime for repairs, savings in oiling labor and savings in lubricant. They know, as do the men in every steel plant in America, that Farval signifies dependable lubrication.

The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm and Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



At right—This Farval automatic system on a 2-high 46-inch blooming mill in the Indiana Harbor Works was installed in 1939. It serves 241 bearings.



Below—A Farval automatic system lubricates 160 bearings on this big 4-high 4-stand continuous cold reduction mill, completed late in 1953.

Maintenance Welding of Heavy Sections

By R. E. METIUS
Welding Engineer
Mechanical Dept.
Bethlehem Steel Co.
Sparrows Point, Md.

. . . . welding with proper structural design can be used in the repair of many heavy pieces of steel plant equipment . . . . welding is thus an indispensable maintenance tool . . . . needed, however, are the ability and willingness to make fullest use of it with right application of controls and engineering . . . .

▲ ELECTRIC welding in its various forms is becoming more and more valuable and necessary as a maintenance tool in steel plants as well as in practically all other industrial plants. In the last fifteen or twenty years, electric welding has progressed from the stage of being a method of repair used only as a last resort to its present stage of being the method of repair and replacement resorted to first. In a large measure, this change is due to the great improvements in the manufacture of coated electrodes, generating equipment, methods of application, and the more widespread knowledge of the metallurgy and techniques of welding.

The quantities of welding wire used for maintenance welding at the Sparrows Point Plant serve to illustrate how useful and how generally applied is this tool under discussion. During the calendar year of 1953, approximately 655,000 lb of coated electric welding wire (including carbon steel, alloy and hardfacing wires) were consumed. In addition, approximately 217,000 lb of carbon steel and alloy steel bare wire in coiled form were consumed in automatic and semi-automatic applications of submerged-arc welding. Using a round figure of 5,500,000 tons of steel ingots produced last year at Sparrows Point, it can be said that 160 lb of welding wire were used for maintenance for each 1000 tons of steel produced.

The bulk of maintenance welding on heavy sections entails the use of electric arc welding on carbon or low alloy steel material. The several examples to be discussed in this paper illustrate the role that maintenance welding can play in repairing, rebuilding and replacing mill equipment.

The first and largest weld repair job to be discussed concerns a cast-steel mill housing on a 110-in. plate mill, as shown in Figure 1. This housing, which weighs approximately 50 tons, fractured during operation, resulting in a complete break through the lower part of the north leg and approximately two-thirds through the upper part of the south leg. The housing was removed from the mill and taken to the machine shop where the two breaks were cut through and the cracks Veed out with oxy-acetylene torches. The faces of the vees were then chipped and ground to smooth surfaces, as shown

Figure 1 — View of 110-in. plate mill shows repaired housing on left.

Figure 2 — Close-up shows break prepared for welding.

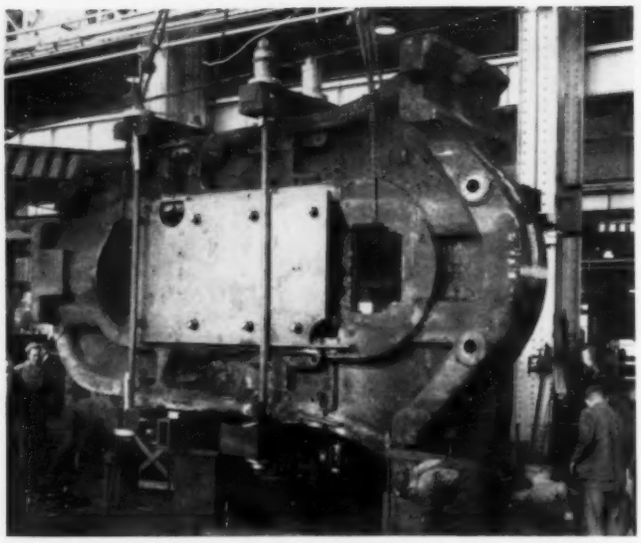


Figure 3 — Tacked and braced housing was positioned for final welding.

in Figure 2. The housing was reset with an opening of 3/16 to 1/4 in. at the root of each joint. The beveled openings were wide enough for accessibility and averaged three inches. At this part of the operation, the housing was on its side for tacking and was set with a plus 1/8 in. in length to compensate for shrinkage. After locating strongbacks across the housing to prevent spreading, fitting plates in the window plate section to prevent twisting and distorting, and welding four 12 × 4 × 1-in. plates across each butt to maintain the opening, the two joints were simultaneously tack welded by depositing five block welds six in. long and six layers deep at each break.

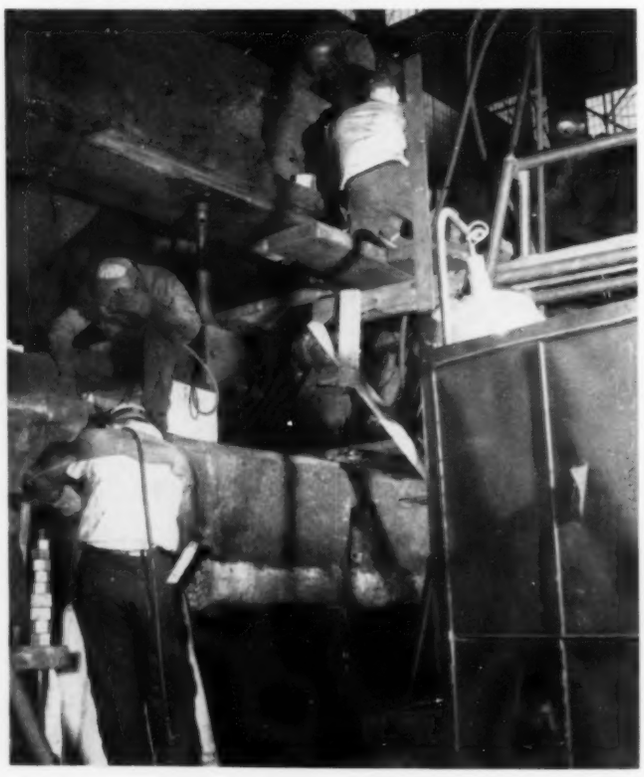
After completing the tacking, the housing was lifted, turned and set up on edge about 42 in. off the floor, as shown in Figure 3. The strongbacks holding the housing were removed, the tack-strengthening plates were also removed and the slabs in the window plate section were relieved of strain by loosening the bolts which held them in place. Four large gas torches were employed to preheat the general area around the two breaks to approximately 400 F. Asbestos blankets were used over the heated sections to protect the welders and to reduce the heat loss from the casting. It was necessary to reapply the heating torches before the welding of the joints was completed. The welding of the two butt joints was then begun by block welding the vertical section of each joint simultaneously to a depth of one-half the depth of the bevel. The slabs in the window plate section of the housing were then removed. The welding of the flanges and remaining vertical webs of the two joints was then carried to completion using up to eight welders at one time, as shown in Figure 4. The use of tram marks at each butt welded joint and a center mark located at the top of the casting made it possible to check and correct uneven shrinkage at the two joints and twisting or swinging of the top or free end of the casting.

After the welding was completed and the blanketed welded joints were somewhat cooler, the housing was placed on its side on a layout table. The window plate surfaces were found to have less than 0.025 in. twist which was overcome when the window plates were replaced.

The housing was reinstalled in the mill and the first slab was rolled through the mill nine days after the breaks had occurred. The repaired housing is still in service after 6½ years.

Figure 5 shows a 7-ft diameter driving gear from a rod mill. A crack developed across the 15-in. wide face of the gear rim and travelled through the web of the gear to a lightning hole. Due to a branching of the crack in the rim, a small section of the rim adjacent to the main crack had to be removed. The cast-steel gear, containing 0.55 per cent carbon and 0.94 per cent manganese, was prepared for welding by chipping the cracked areas and preheating the entire gear to about 250 F, and the local area to be welded to about 400 F. All weld deposits were made using Type 308 stainless steel (18-8) electrode. The pocket or hole in the rim

Figure 4 — Eight welders working at one time gave simultaneous all-position welding of housing breaks.



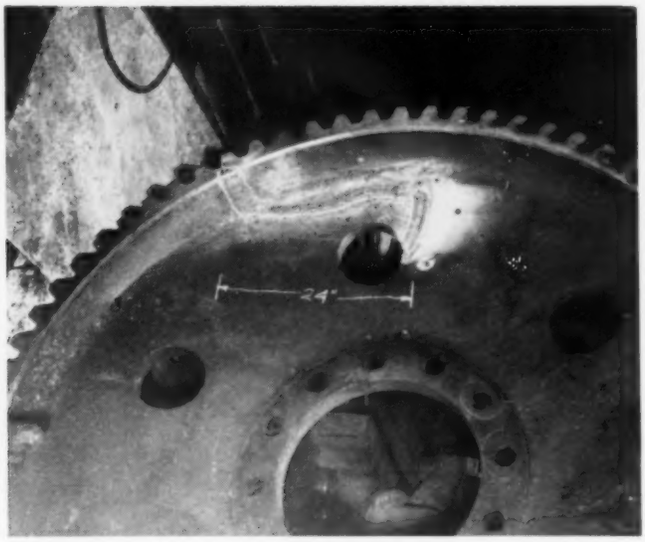


Figure 5 — Rod mill gear shows welded crack.

was welded first, followed by the rim crack and then the web crack. Clamps and flat bars applied across the tooth face to eliminate the axial displacement in the rim and the use of tram points across the butt weld, coupled with pneumatic peening of all weld deposits, made it possible to complete the weld repair so that only hand grinding of the adjacent gear teeth and rim was required before returning the gear to the mill. No furnace stress-relieving treatment was applied to the gear to prevent scaling of machined surfaces.

The repair job of chipping, welding, grinding and refitting the gear with new bolts was estimated to have saved about $2500 compared to the cost of a new gear. The repaired gear has now been in service for over 4½ years. Other large high-carbon gears with cracked rims and webs have since been successfully repaired in a similar manner.

Figure 6 shows a view of the coiler mechanism and downcoiler extractor fork in a 68-in. hot strip mill. The function of the extractor fork is to push the coil of steel off the mandrel onto the cradle. The original forks, machined steel castings, very soon began to crack and break into pieces, requiring regular repairs. In a successful effort to obtain longer service between repairs, an extractor fork was fabricated from low-carbon steel plate and welded with the low hydrogen type electrode, as shown in Figure 7. The service life of the fork was increased and a saving of about $2000 was realized, compared to the cost of a purchased fork. Fabricated forks are now the rule rather than the exception.

Figure 8 shows a cold strip mill back-up roll extractor in the process of removing a back-up roll from the mill stand. This particular extractor, weighing approximately 38 tons, broke into two pieces early this year while making a lift on a roll to remove it from the mill housing. The broken lower half section maintained its position on the neck of the roll and the upper half remained suspended from the crane. After disconnecting the upper half, the lower half was removed by passing a cable through a large hole that was quickly and inadvertently burned in the web of the lower section. Figure 9 shows the fracture and burned hole in the lower section of the 0.28 per cent carbon cast-steel extractor. Note that the fracture originated at the inner corner of the 4-in. thick tension flange and progressed in a brittle manner across the 3-in. thick web of the 36-in. wide beam.

The broken extractor sections were moved to a large mill annealing furnace and fully stress relieved by soaking at 1150 F for about 27 hours. After moving the sections to the machine shop, the fractured ends were cut back by drilling and machining, and finish machined with a double J-bevel preparatory to welding. The V-shaped section, as shown in Figure 10, was fabricated from 0.30 per cent carbon rolled material, furnace annealed, machined with J-bevels and set in place as shown. This replaced the original section that was removed due to the burned hole. This replacement section was preheated to 300 F and then welded to the lower section of the extractor casting. The joint was welded simultaneously from both sides, first in the web and then the flange. Alinement of the insert was checked by means of a fixed pointer and center-line and maintained by welding and peening.

Following the completion of the butt joint between

Figure 6 — Hot strip coiler shows extractor fork in operating position.

Figure 7 — Close-up of fabricated coiler extractor fork.

Figure 8 — Repaired back-up roll extractor is removing a roll.

Figure 9 — Fracture face and burned hole in extractor casting are shown.

the insert and the lower section of the extractor, the welded section was turned over and positioned with the upper section of the extractor ready for the second butt weld to be applied, as shown in Figure 11. The area was reheated to 300 F and welded in the web and flanges as on the first joint. Alinement of the upper section of the extractor was checked by means of a fixed pointer and centerline and maintained by welding and peening. The entire extractor was turned over once more to complete welding on what had been the overhead sections of the two flange butt welds. Before and after the welding of the insert, the edges of the tension flange of the extractor were surface ground and checked for cracks and sand inclusions by using the dye penetrant method. All such imperfections were removed by pneumatic chipping and all chipped areas restored by welding.

A closeup of the inserted section welded into the extractor is shown in Figure 12. The completed butt welds in the insert and to the casting are shown and the initial web block welds in the second butt are apparent. The V-shape to the insert was due not only to the fact that it did replace the original section containing the burned holes in the web of the casting, but also to the desire to have both welded joints run diagonally across the beam for the greater total joint strength attainable.

After all welding was completed, all weld deposits in the tension flange and web were surface ground flush with the adjacent casting and checked for cracks. The completed extractor was then returned to the furnace and stress relieved at 1150 F for nine hours. After being painted and refitted, it was service tested and has now been in full roll-changing service for seven months.

Since this first back-up roll extractor repair job, a second cast-steel extractor was broken in service and successfully repaired in a similar manner. Other unbroken extractors are gradually being removed from

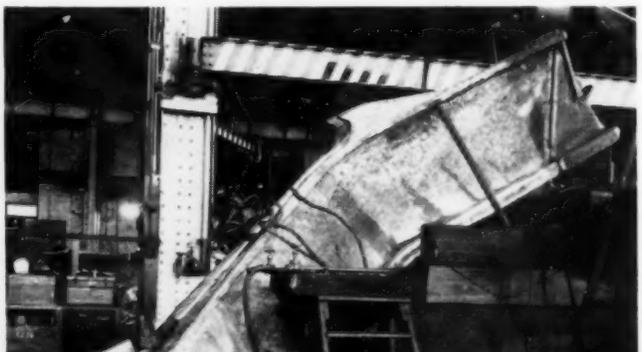
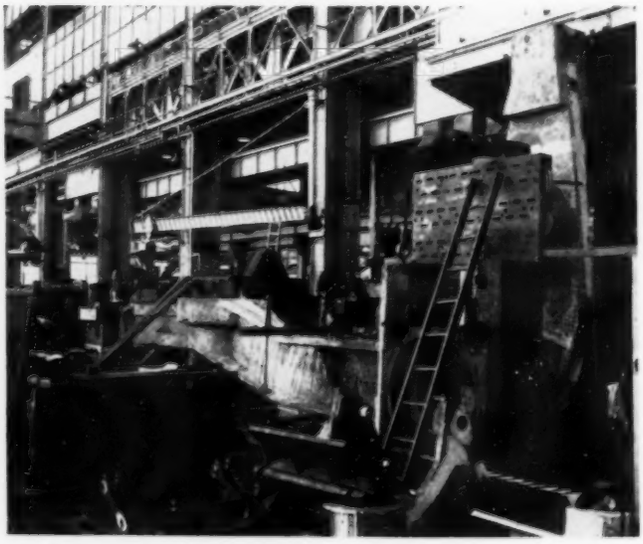


Figure 10 — Joint between extractor section and insert was welded initially.

Figure 11 — Second joint to be welded was between insert and upper extractor section.



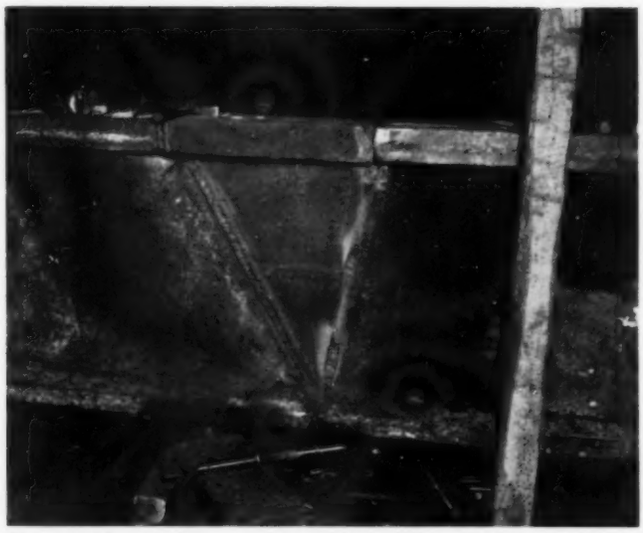


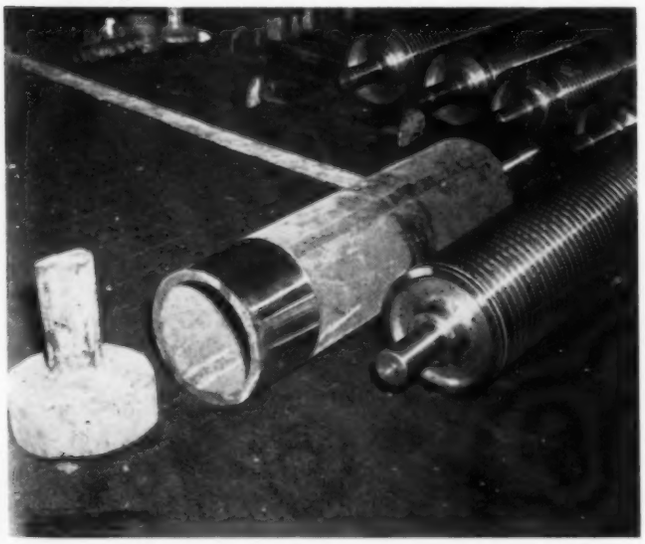
Figure 12 — Close-up of insert section and weld joints shows diagonal direction selected for additional strength.

service for a stress-relieving treatment and inspection and repair of any surface irregularities in order to prevent any future failures.

Figure 13 shows a few of the 100 odd fabricated 12-in. diam rolls that have been made for the electrolytic tin plating lines. The body of the roll was formed by submerged-arc welding two half-cylinders together. The longitudinal edges of these half-cylinders had been torch beveled for welding. The two forged necks were rough machined and submerged-arc welded to the rough-machined roll body. After finish machining and balancing, the completed rolls were delivered to the mill at a savings of about $160 per roll compared to the pierced forging type of roll that these replaced.

A rather unique roll was fabricated to replace some cast iron 25-in. diam sheet scrap baller rolls that were regularly being broken in the neck area. Figure 14 shows a sketch of the fabricated roll made by sandwiching flame-cut doughnut sections of thick rolled material, submerged-arc welding each layer to its adjacent layers, boring the center of the layered body, and pressing in a 6-in. diam steel shaft which was then

Figure 13 — Fabricated electrolytic rolls were made by welding.



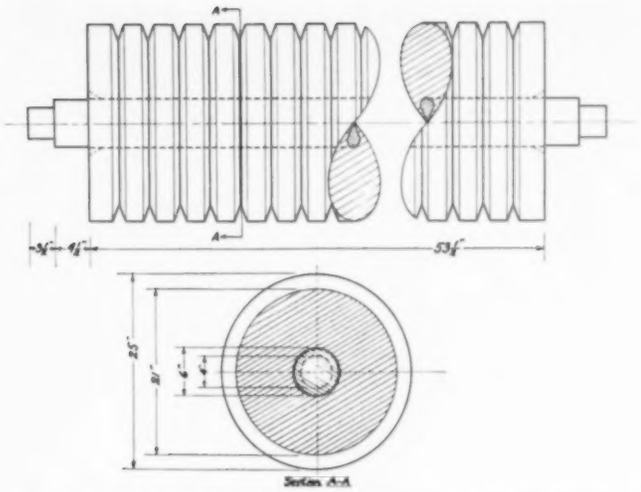


Figure 14 — Fabricated scrap baller roll has given good service.

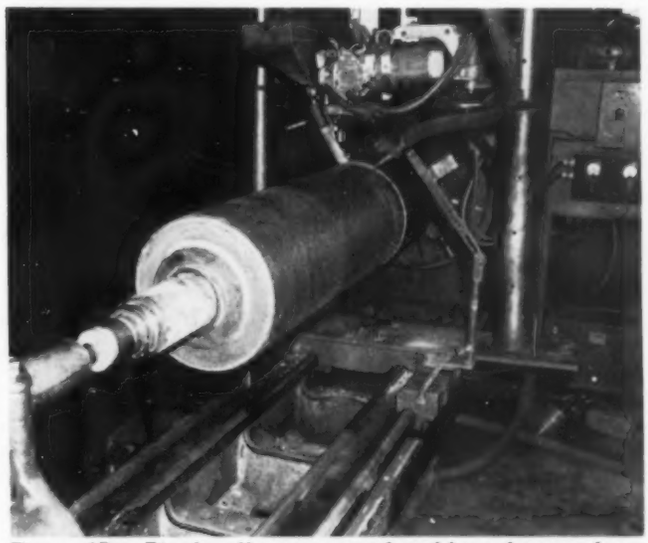


Figure 15 — Pinch rolls were resurfaced by submerged-arc process.

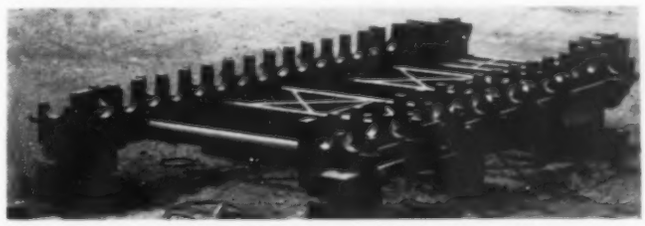


Figure 16 — Overall view shows fabricated 160-in. plate mill lift table.

bevel welded at the ends of the body. If and when these steel necks are broken or worn out, the necks and shaft can readily be renewed by cutting away the welds, pressing out the old shaft and installing a new shaft. The several installations of these rolls have been free of breakage after many months of service.

Resurfacing and rebuilding of worn surfaces undoubtedly consumes most of the coiled welding wire used at Sparrows Point. Items such as piston rods, hydraulic plungers, table rolls, crane brake wheels and pinch rolls are but a few of the variety of mill parts that can be and are being resurfaced by welding with one of the many steel or alloy-steel wires available. Figure 15 shows typical submerged-arc resurfacing equipment applying a 12 per cent chrome stainless steel weld

Figure 17 — Close-up of welded sections of plate mill table.

deposit to a 16-in. diam pinch roll used in a pickler line. The 500 Brinell, ¼-in. thick deposit has given a service life equal to the original carburized roll surface at a cost approximately $1000 lower than that of a new roll.

About three years ago, it was found necessary to replace the original cast-steel lift table on the back or discharge end of a 160-in. plate mill. The original table had become so corroded and deteriorated over the years that further patching by welding was impractical. After careful analysis of all factors, it was decided to fabricate a replacement table of welded construction and of improved design. Figure 16 shows an overall view of the new 60-ton table made of rolled steel slabs with the exception of two cast-steel sections at the housing or narrow end of the lift table. Figure 17 shows a close-up of one of the main side girders composed of the one-piece vertical member and the various line shaft and bearing supports and braces. All weldments were machined with J-bevels for 100 per cent fusion welds with the exception of several heavy joints where the strength obtained from a 100 per cent welded joint was unnecessary. In those cases, a specially machined joint (see girder end in Figure 17) was used that eliminates root stress in a welded joint without making a 100 per cent weld. After the welding was completed on the two main girders, they were furnace stress relieved and finish machined.

Figure 18 — Joining of table side girders and cross spreaders required close checking for shrinkage.

The final fabrication step consisted of setting the two machined assemblies in their proper position, as shown in Figure 18, and welding the three large fabricated spreaders to each side girder. Shrinkage of the welded joints was allowed for in the setting of the two side girders and shrinkage and twisting were carefully watched through the use of feeler gages, the long round spacer bars and centerline pointers.

The table, installed in the mill in July, 1953, complete with the forged rolls, gears and shafting, has been found structurally sound. A second lift table for the entry or front end of the mill is now under construction and will be installed within the next year.

The typical jobs just described illustrate the use that can be made of welding techniques coupled with proper structural design in the repair and maintenance of heavy units in a steel plant. Welding is an indispensable maintenance tool. All that is needed is a willingness and ability to make the fullest use of it with application of proper controls and engineering.

DISCUSSION

PRESENTED BY

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

R. E. METIUS, Welding Engineer, Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

C. E. Pritchard: Have you made any comparison in your overall picture whereby you could evaluate arc welding with the thermit welding method, cost-wise, and practicability-wise?

R. E. Metius: You are wondering why we did not use thermit welding on several of these repair jobs such as the plate mill housing. At the start of that particular job, thermit welding and manual arc welding were the alternatives being considered. As I remember, the major point under discussion was which method would enable us to finish the job the fastest. At the time we did not have the proper sized crucibles, torches, etc., for thermit welding of such a large housing, whereas we could set up immediately to prepare for manual arc welding of the housing. Thermit welding was considered, but the decision to use manual arc welding was primarily based on our ability to return the repaired housing to the mill more quickly.

C. E. Pritchard: It was purely a matter of the time, rather than distortion or cost differential?

R. E. Metius: That is essentially correct. The question did come up about distortion, but I feel we conquered that. If thermit welding had been in regular use in the plant for repairing large sections and proper equipment and trained personnel available, it is possible that such a method would have been used since actual welding time would have been considerably shorter.

Problems in Operating and Maintaining steel plant equipment

. . . . with changes in operating requirements and practice, the maintenance man must revise his maintenance procedure . . . . close cooperation between the operator and the maintenance man is thus necessary to prevent problems before they occur . . . .

By JOHN F. OEHLER
Electrical Foreman
Strip Mill Division
Bethlehem Steel Co.
Lackawanna, N. Y.

▲ STEEL mill equipment, in this paper, includes steel rolling and processing equipment and does not cover the raw product and steel melting equipment, although many of the latter units are similar in construction and application. The hot and cold strip mill at the Lackawanna plant has representative equipment from various manufacturers necessary for the following operations: slab handling, scarfing, reheating prior to rolling, hot rolling, hot shearing and piling, and coiling in the hot mill; continuous pickling, tandem cold rolling, annealing and skin-pass rolling in the cold mill; shearing, slitting, roller-leveling and oil-processing equipment in the finishing departments of both mills. This equipment is used in the production of a quality product of flat rolled steel sheets and plates in large quantities and in widths varying from 24 to 72 in. and thicknesses from 0.012 to 1 in.

The purpose of this discussion is to develop some of the general and specific problems that arise in the operation and maintenance of the equipment, in order to produce a stimulating discussion between the two groups working with the equipment. Some examples will be given to show the solutions to the problems as they presented themselves.

DIVISION OF TIME BETWEEN OPERATION AND MAINTENANCE

The operating personnel may be said to be wearing the equipment out while the maintenance personnel are working to keep the equipment in repair. This problem then presents itself — how many eight-hour turns a week should the equipment be operated and how many turns should it be down for repairs?

The division of time that has worked out satisfactorily for maintenance at the Lackawanna plant is eighteen operating turns and three repair turns. In a major unit operated on this basis, the repair day should be staggered with relation to the other major units. This allows the work load to be distributed for a given number of maintenance men available each day. Additional downturns above three turns are to the advantage of the maintenance department. Deviations in the direction of less than three turns are encountered when operating difficulties occur and when there are peak production periods. In such cases the operating schedule may go to nineteen or even twenty turns. The maintenance groups are kept on the defensive with such a schedule, and must make careful checks of the equipment to see whether any trouble points are developing, so that additional repair time in preference to production time may be requested. The effect of a major breakdown during the middle of a rolling schedule is no doubt understood by all concerned.

An example of the request for additional repair time above the three turns occurred when a damaged interpole on the lower half and drive side of a 4500-hp, 600-volt, d-c motor had to be changed. The work of removing the interpole called for lifting off the top half of the motor and then taking out the armature. Request was made for forty-eight hours. The rolling schedule was such that the operating group felt that they could not afford that much downtime and still maintain the schedule. After reviewing the work a twenty-four hour down period was finally agreed upon. The mill was scheduled to roll an extra eight hours one week to allow for twenty-four hours down the next week. Preparations really started two weeks in advance of the shutdown. The part of the concrete foundation

which would be in the way during the horizontal withdrawal of the interpole from the frame of the motor was chipped away on each of two regular weekend shutdown periods. An interesting, but provocative sidelight on the chipping job, was that with all the concrete in the big foundation, a 1 × 3 × 12 in. piece of misplaced shim stock would be right in line where the interpole was to come out.

The interpole was changed and the downtime was twenty-five hours. Although the operating people usually are happy with such results, they will probably add "Can you do the job in twelve hours next time?" The experience gained may at least allow the maintenance group to improve the time, but better still, that job does not occur again.

Maintenance of the overhead traveling cranes during an extended peak production period is another example of a request for scheduled downtime. There were about forty-five cranes at that time, ranging from 15 to 70-tons capacity. The delay on production units resulting from breakdowns of cranes was increasing and something had to be done to reverse the trend. A two-hour period was requested during the week so it would not be necessary to repair all the units over the weekend when various production equipment was down. To establish this routine, two or three cranes had to be down for inspection and minor repairs each eight-hour turn during the first six days. The maximum number of maintenance men available were scheduled to work on the crane during the two hours. This scheduling helped to cut down the annoying short-time breakdowns and also allowed for an inspection of major troubles that were developing. Any major repairs were then scheduled at a time best suited to both departments. The overall downtime for repairs was thus reduced considerably.

HANDLING OF EQUIPMENT BY THE OPERATING PERSONNEL

Not all maintenance work is due to wear alone. Mishandling of mill equipment causes much of the minor and major repair work required during the week. The mobile equipment, an important facility in the operating department, is a good example how much damage may occur from handling, not only to the mobile equipment itself, but also to stationary equipment hit by swinging loads and magnets.

Side pulling with the hook block of an overhead crane is a simple illustration. Most crane operators know that if the hoist and bridge are operated at the same time the cable will come off one or more of the sheaves, especially the upper sheaves. Many repair calls and cable changes result. Slotted plates have been installed below the upper sheaves on most of the cranes so that the cable can pass through the plate and always remain vertical with relation to the upper sheaves when a side pull is made. This prevents the cable from coming off. There is more wear on the cable if too many side pulls are made, but in general the cable life is much better. A cable that comes off the sheaves is usually pinched and in most cases has to be replaced.

Overloading of cranes and tractors initiates a whole series of problems. This is especially so where there is initial high wheel loading and the overloads are picked up by the hoist. Loss of the camber in the main crane girders, crushed bearings, broken axles, excessive wheel-tread, runway-rail and rail-joint wear and motor failures result. The effect of these loads can easily be checked by inspecting a pair of driver wheels. The cage side will always be worn more than the side opposite the cage, due to the additional load of the cab and air conditioning equipment where such is used. Furthermore, most of the loads are usually handled on the cage side. Overloading of other equipment brings similar results.

To prevent overloading, close co-operation with the operating personnel and continual checking by the maintenance department are required. In the case of slab handling, the operating department has made a table for all slab sizes, with weights and the number of slabs that may be picked up in one lift, on the basis of the crane capacity. The crane operators, hookman and maintenance men are given a copy of the table so there will be no question about the weight that may be lifted. However, there are times when it seems easier to pick up a double lift, or one or two extra slabs, to make only one trip with the crane instead of two trips. Record is made of violations of this kind, if detected, and the persons responsible are punished if they are repeated.

Replacement of the crane or addition of another crane of sufficient capacity to handle the material may be necessary. A case of this came up when the operating department needed additional crane service to change the work rolls of the tandem mill stands. The crane used to handle this work was a 25-ton unit. The load consisted of the work roll and counterweight and weighed about 35 tons. This proved to be too heavy for safe handling, so the capacity of the hoist was changed to 35 tons. This was accomplished by changing the reaving of the cable, the addition of another brake, and the changing of the accelerating and dynamic resistance. These changes allowed the crane to pick up the load, but when the roll had to be spotted within an inch or so to enter the housing, the change did not prove successful. A 60-ton crane, similar to the other two cranes doing that work, was purchased and installed. The converted crane was moved to another building where an additional crane was needed.

The majority of the cranes at the strip mill are single-motor bridge drives, using line shafts and end sections of line shafts to connect to the driving wheels. Quick stopping, bumping of cranes together, and skidding on one runway rail and not on the other, have caused many end sections of line shafts to break. The break usually occurs at the point where the shaft is necked down to go into the bearing. This problem was overcome by changing the design rather than by making exacting requirements on the crane operators. The forged steel shaft was replaced with an alloy shaft of the same diameter throughout the length. The part of the shaft where the bearing is mounted serves as the inner race of the bearing, thus giving an increase in size of the shaft where the breaking occurred, as well as the increased strength of the alloy composition.

Other problems arise from the fact that the cranes are operated continuously during the rolling period and must also be available during downtime for mechanical repairs on mill equipment. A crane operator wants his crane to run smoothly and without vibration or pound-

ing at the rail joints. It should be able to stop on a dime. In order to meet these requirements, the runway supports and alinement of the rails must be the best that can be provided. The major problem then becomes one of proper relation between the life of the rails and the life of the wheels. All rails initially installed at the Lackawanna strip mill were 105-lb tee rails originally designed for railroad service. The crane loading conditions in a number of buildings resulted in the splitting of the rail underneath the head. A 104-lb crane rail was substituted and no more cracking under the head was encountered. This rail is not as high and has a thicker web, but the head is narrower. Its head is crushing and widening out at a faster rate than the head of the original 105-lb tee rail. The use of a 135-lb crane rail with a wider head is presently being considered.

The ends of the rails have a way of battering down and chipping under the continuous operation. This makes for a rough ride and it is not long before the crane operator is complaining for safety reasons. Originally the rails were 33 ft long. This has been increased to 66 ft, thus cutting the number of joints in half. On account of shipping conditions, the 66-ft rails are no longer available. A 60-ft crane rail of 135-lb section is now available which can be shipped without trouble and should be a good compromise on length in order to keep the number of rail joints to a minimum. The ends of the rails, the splice bar and rail drilling, and the diameter of bolts used should be such that a tight joint can always be maintained.

A number of conditions must be considered in the choice of crane wheels. The driver wheels are most important and the cranes at the strip mill are equipped with tapered wheels. These wheels have to be matched and the hardness has to be selected to give the best compromise between changing of wheels or changing of rails. A wheel that is too hard soon spalls; if too soft it wears out in a short time. The wheels being used are 450 to 500 Brinnell hardness and matched to within $\frac{3}{32}$ in. on the circumference. These conditions may give satisfactory operation, but if the crane can be plugged and skidded, flat spots develop on the tread of the wheels and the operators will complain again.

Continuous running of other equipment, such as roller lines and high-pressure sprays, when the equipment could be shut down, has led to the application of load relays, photo-electric units and limit switches for the automatic starting and stopping of such equipment. Application of self-centering switches has also helped where the operator might start a unit and then walk away, leaving it unattended.

CHANGES IN PRACTICE

The conveyors taking the hot strip of steel from the finishing stand to the coiler or the piler first looked like very simple units which would not require much maintenance. Addition of large quantities of water for cooling the steel, the heat of the steel itself, and the use of magnets to straighten out a pile-up of steel on the roller line, resulted in maintenance problems that grew as the tonnage output of the mill increased.

The first change was made in the section of roller line that conveyed the cut-to-length sheets from the coiler to the piler. This roller line was driven by 105 motors rated at 1.37/5 hp, 147/440 volts, 550/1750 rpm, 20/60 cycles. Each motor operated two rolls by means of a small steel pinion on the motor meshing with a cast iron gear mounted on the end of each roll. The operating conditions mentioned resulted in broken and bent shafts on the motor and chipped and broken teeth on the cast iron gears, as well as bearing and motor-winding failures. In an attempt to correct this condition, a "V" belt drive was mounted on a spare frame and set of rollers. The unit was set up on the floor away from the roller line but connected to the circuit so that the same starting, accelerating and stopping conditions could be observed. The motor had a four-grooved pulley and each of the rolls had a two-grooved pulley, which was the maximum number that could be put on. Type "B" V belts were used. The operation of the drive appeared to be satisfactory. The problem now was to get the pulleys in the same space the gears and pinions occupied, and to make the motor mountings adjustable for belt-tension correction. Drawings for layout and material required were developed and finally the changeover was started. There were about three or four spare units available. These were sent to the machine shop where the changes were made. Thus the line was kept running by changing a few units at a time during shutdown periods. The layout is not as good as if completely new units of a similar design were installed, but the line is operating satisfactorily. There are very few motor failures on the line, and the mill delays, maintenance costs and damaged steel have been reduced. The oil in the gear box and the conditions resulting from oil leakage due to the high temperature of the steel have been eliminated.

Prior to 1949, the section of the table rolls between the last rolling stand and the coilers were driven by 2.5/7.5 hp, 110/440 volt, 490/1715 rpm, 20/60 cycle motors with gear box attached. A rubber-ball type coupling was used, in order to reduce shock in starting and stopping. The bearing housing for the roll was of the suspended type; due to heat conditions, vibration, stretching of the bolts and general operating conditions, the bearing cap would drop a small amount. The rubber ball would first be chewed up and then the rubber ball separators would hit and be knocked off. These disturbances would also be carried back into the gear box causing failure of gears and motor-windings. The small motor pinion in the gear box would take a beating. Water, flowing in abundance, would find its way into the gear box. The complete unit of frame, roller and motor had to be removed from the line and turned over to make a satisfactory repair. A good share of the weekend repair turns was spent on this work.

A speed increase for the entire line was requested by the operating people to meet other changes in equipment and at that time the request for a V-belt drive was made. The manufacturer was reluctant to furnish this type of drive but finally agreed. There are now some 224 motors, 5-hp, 440-volt, 1145-rpm operating at 25 to 80 cycles. The motors are standard and can be changed during short shut-down periods. Any severe service on the roller line is cushioned through the V-belts. A considerable number of belts are changed and motors fail due mainly to water conditions, but the overall picture as far as maintenance is concerned is much better, and the time saved on weekends is used to better advantage on other maintenance.

Changes in practice and requirements usually involve speeding up the equipment, closer speed regulations, installation of X-ray units for measuring thickness, width, gage, extensiometers, communication systems and air conditioning. This type of equipment presents the maintenance department with the problem of securing and training personnel in its use and upkeep. The more the operating department finds out about the advantages the new equipment provides in producing a better product, the more important that the maintenance group keeps the units from being out of service for repairs. Technically trained men have worked out best to date, but the technical high school or vocational school graduates also appear to be good material. To service this type of equipment properly, the maintenance man must understand some of the operating department requirements. A sample illustration is the case where an X-ray unit is reading off gage. Suppose the unit is found operating satisfactorily from the electrical end. What next? The test strips of steel, made for comparison by the operating people, are checked. They are found to be a few thousands of an inch off, which corresponds to the error shown by the X-ray unit. Why are the test strips off? No one inspector apparently applies the same pressure to his hand micrometer or the micrometer is not checked for zero. To remedy this situation, the maintenance man is supplied with a preset type hand micrometer. This allows him to make an accurate check even though he is not using the micrometer every day.

Many other problems are continually developing between the operating and maintenance groups. An item that really can stir up discussion would be the responsibility for delays in production caused by the failure of a piece of equipment or an error in the rolling practice. Did the operators overload the equipment, wrecking the mechanical driving gear which in turn flashed or roasted the electrical motor — or was it the other way around? Such problems provide endless discussion.

Roll Neck Bearing Design -- Developments and Trends

By R. L. HUMPHREYS
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. . . . engineers and designers have many different opinions on bearing material, grooving, lubricants, shields, and so forth . . . . quite often designs which operate well in one mill may not do as well in another mill . . . . some of the many procedures used are covered in this paper . . . .

▲ THE title of this paper may be somewhat misleading in that it is not intended to be industry-wide in coverage, but is limited to some of the most interesting design changes and developments that have occurred at the Sparrows Point Plant. This discussion primarily concerns the open type babbitt, babbitt-bronze grid and fabric bearings and no attempt is made to evaluate developments or designs of anti-friction and radial oil-film type bearing. There undoubtedly are other developments possibly of more significance in other Bethlehem plants and in the plants of other steel companies, but the facts and details of these were not readily available at the time of the writing of this paper, and therefore cannot be discussed.

The roll neck bearing is one of the most important mill component parts involved in the rolling of steel. Much of the success in rolling a satisfactory product is dependent on the performance of these bearings. Premature failure results in mill "downtime" and it is an axiom among mill people that a bearing must always last to the next scheduled repair day. This generally is the case, for in most instances, wear is so gradual that unexpected sudden roll neck bearing failures are rare.

Bearing performance is usually determined in terms of tonnage rolled. This perhaps is the most important criterion; however, there are other factors such as friction drag, cost of lubrication, cost of initial installation and replacement that must also be given consideration. In development work of any kind, any one of these conditions may be subject to improvement. It should not be implied that the bearing material lasting the longest is necessarily the best to use. There was one case in Sparrows Point where an exceptionally hard fabric material wore down a roll neck though the bearing itself stood up beautifully. In some mills, power is at a premium and a reduction in power alone means a considerable saving. In some designs, initial costs are quite high, but when considered in the "long run," they

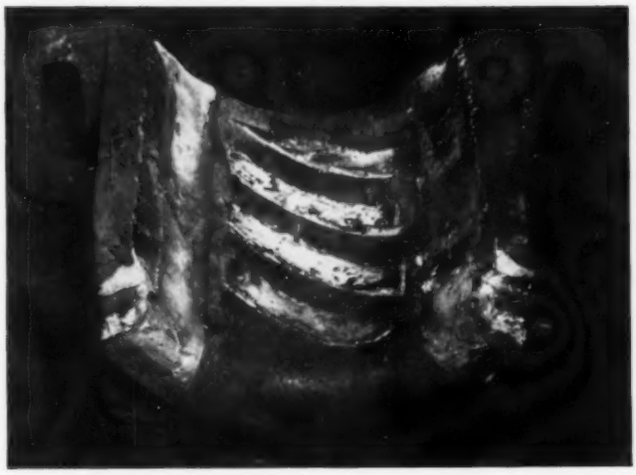


Figure 1 — A babbitt bearing with bronze insert was originally furnished on all stands of No. 1 rod mill.

Figure 2 — This rod mill stand has babbitt and bronze insert bearings installed.

Figure 3 — This typical fabric bearing is now in use in No. 1 rod mill.

Figure 4 — Anti-friction thrust bearing installation shown is used on some stands in No. 1 rod mill.

may be found much less costly to maintain. In the last analysis, the best combination of all factors, including the lubricant, method and frequency of lubrication, location of grooving as well as bearing material, which will lower the cost per ton rolled, is the correct combination.

Rod and bar mills have possibly undergone more bearing design changes than any other type of mill. A good example of the process of development of bearings may be found by tracing the history of Sparrows Point's No. 1 rod mill. Originally these bearings were of babbitt with bronze inserts, as illustrated in Figure 1. Figure 2 shows a mill stand typical of this particular bearing installation. Tonnage life was very poor. In fact, in 1928, an average of 90 finishing mill bearings and 20 roughing mill bearings were changed per month. The mill, at this time, was rolling two strands and operating one to two ten-hour turns per day. In the early 30's, lignum vitae and many types of fabric bearings were tested. By 1937, fabric bearings were installed in all stands above No. 3 roughing stand. These fabrics are water lubricated without any addition of petroleum lubricant and are as shown in Figure 3. This resulted in a decrease in power consumed from about 114 to 74 kwhr per ton, or a reduction of 35 per cent. Starting approximately five years ago, the conventional thrust bearings on the top and bottom rolls on the working side of the mill, on No. 6, 8, 10, 12, 14, 15 and 16 stands were replaced by ball bearings. Figure 4 shows a mill stand with the anti-friction thrust bearings installed. The better mill alinement and lower starting torque resulting from this change further reduced the power consumed, giving an average of 61.4 kwhr per ton for the year 1954, even though the mill was rolling three strands with a heavier bar. From the best sources available, bearing replacement is now about 24 babbitted and two fabric bearings on the roughing stands and one fabric bearing on the finishing stands per month. Fabric bearings in the No. 0 through No. 3 stand were never too successful because of the slow surface speeds and scale condition.

No comments concerning rod mill bearings would be complete without some remarks pertaining to precision, babbitted sleeve type bearings. While the initial cost for both the bearings and the necessary oil systems is much greater than it would be for the open check type babbitt or fabric bearings, the higher tonnage life, ability to hold gage, and low maintenance cost of these bearings appear to indicate that this cost is justified. The No. 2 rod mill is equipped with bearings of this type. The fifteen roughing stands of this mill roll four

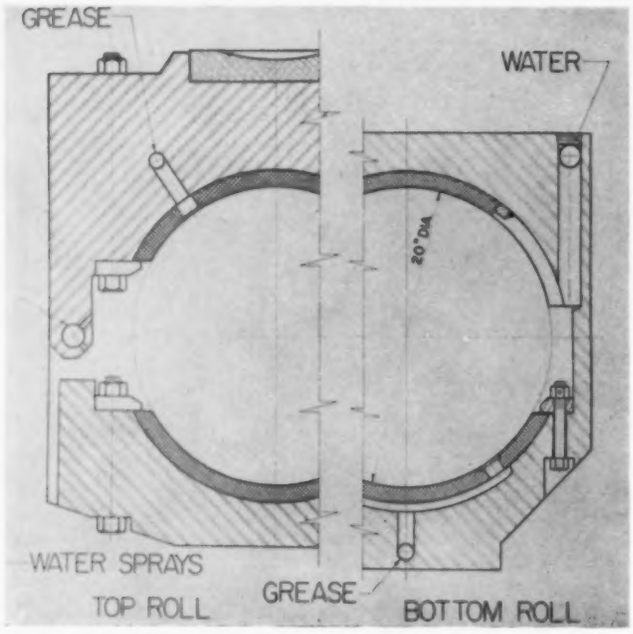


Figure 5 — Sketch shows enclosed fabric bearing design used in 30-in. horizontal billet mill.

strands and the other twelve stands are arranged as two sets of six stands each. These finishing stands are two strand mills. For the twenty-seven stands, approximately eight bushings are rebabbitted per month, due mainly to normal wear.

A molybdenum disulphide impregnated fabric bearing has recently been tried in the No. 1 stand or scale breaker of the 56-in. hot strip mill. Regular molded, phenolic resin bearings of coarse weave cotton cloth had been used in this installation for years. The average life obtained was approximately three months of continuous service. Starting on June 6, 1954, two sets of rolls were built up, one with the regular bearings and one set with bearings of the standard type, but impregnated with molybdenum disulphide. Standard procedures were followed when these were placed in service; each set has alternately operated two weeks and has been out of service two weeks since the start of this trial. In December, after an accumulation of three month's operating service, the bottom standard bearings had to be replaced because there was about $\frac{3}{16}$-in. wear on the drive side bearing and the surface was rough; however, the work side bearing had $\frac{1}{8}$-in. wear and had a fair surface finish. In comparison to this, however, the impregnated bearing had about $\frac{1}{16}$-in. wear on the drive side and possibly $\frac{1}{32}$-in. wear on the work side. The surface condition of these bearings was good. Most of the wear on this trial set of bearings occurred during a period in which they were inadvertently run with approximately 60 per cent of the water sprays clogged. The actual length of time they operated with reduced water is not known, but it was possibly a period as long as 32 hours. At the end of January of this year, there had been no appreciable wear since the December inspection.

One fairly recent development in the field of fabric bearings is the fully enclosed bearing. These are now being used on a large number and variety of mills. In the Bethlehem Corporation, two stands of a rod mill, the work side top and bottom bearings of a 134-in. plate mill, two stands of a 21-in. horizontal billet mill, and one horizontal stand of another 30-in. billet mill are so equipped. The latter installation has only been in operation since January 31 of this year, but as for the others, good results thus far have been reported for each. The principal function of this design is, of course, the elimination of practically all mill scale from entering the bearing. The actual bearing and housing design for the various installations has nearly as many variations as there are installations. Figure 5 is a sketch of the design of the enclosed fabric bearing in use in the 30-in. horizontal billet mill stand at Sparrows Point. Figure 6 is an actual view of the top bearing showing the grease grooving, water sprays, composition scale shield, and method of securing the fabric liner in the housing. Figure 7 shows the grease grooving, single water inlet, liner securing arrangement, and composition thrust segments for the bottom bearing.

Another interesting development in roll-neck bearings occurred on the 40 × 80-in. slabbing mill at Sparrows Point that went into operation in September 1936. The original bearings furnished for this mill were duplicates of those used on the 46-in. blooming mill installed in 1926. A pressure grease system was used to lubricate

Figure 6 — Actual view of top enclosed fabric bearing for 30-in. mill.

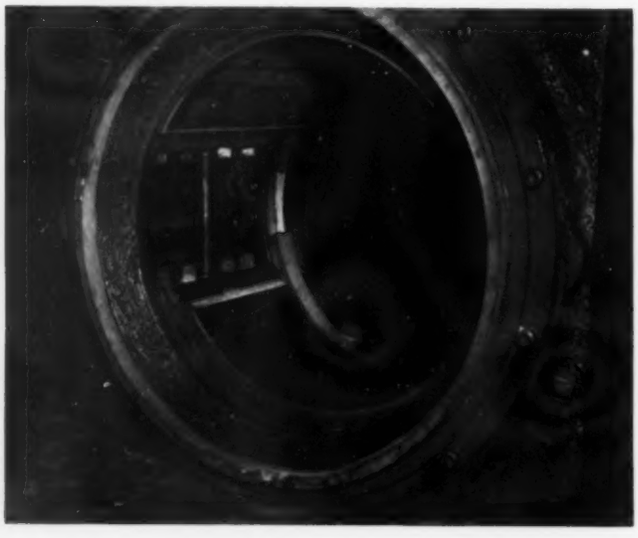


Figure 7 — Actual view of bottom enclosed fabric bearing for 30-in. mill.

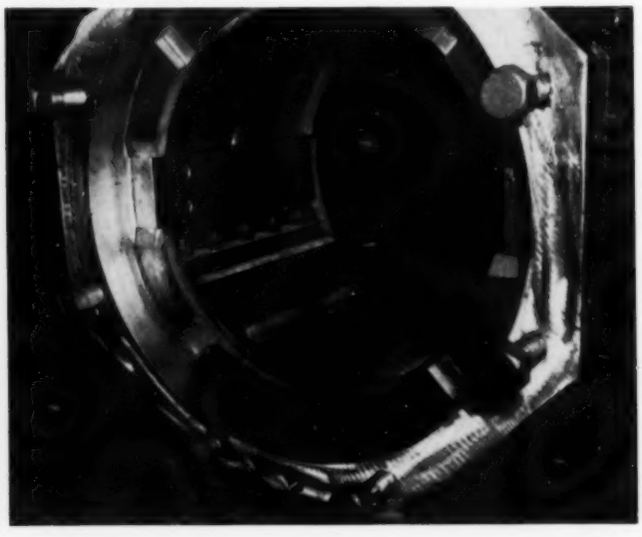


Figure 8 — This 40-in. x 80-in. slabbing mill bearing has four grooves.

these slabbing mill bearings from the start. Early experiences with the 46-in. mill had indicated that some difficulty would be encountered with the bearings on this slabbing mill. These bearings were of the conventional babbitt-bronze grid type and the percentage of phosphorous bronze to lead babbitt was approximately 50-50. Two grease grooves were cut axially in the bronze grids, one on each side of the bearing center. These two grooves originally supplied the lubricant to both the radial and the thrust surfaces. From 1936 through 1938, little rolling was done on this mill but bearing changes were frequent. In 1939, production was increased to supply slabs for the hot strip mill and troubles with the bearings and roll necks became acute. Fire-cracked roll necks were a major problem and the average bearing life was about 300,000 tons. Observation of these bearings showed that very pronounced wear occurred in the radial bearing close to the thrust end. The drive side bearing wear was three to four times as great as the wear on the off-drive side. The center bronze grid was removed early in 1940 with some noticeable benefit. Fewer hot necks occurred, but the life of the bearings was not improved to any great extent. Following an investigation as to what other similar mills were using, it was decided to do away with the grids entirely and use the plain babbitt bearing.

For these new bearings, four sets of grease feed lines to four separate grooves are used. Figure 8 shows two views of this altered and presently used design. The original two grooves remained but are now in the babbitt instead of the grid. These grooves are 2 in. wide and go completely through the babbitt to the casting, tapering to 1¼ in. at the bottom. They extend to within 2 in. of the thrust end and to 1½ in. of the other end. A third groove is cut into the radial bearing, 13 degrees off dead center, at the point where the radius of the thrust bearing begins. This groove is 2 in. wide and 6 in. long. The fourth groove is a separate feed to the thrust bearing. This is a poured bearing and is machined to roll neck size.

The use of this type bearing has eliminated entirely the fire cracking of roll necks. Rolls are now discarded after full rolling life has been obtained and the necks still show a smooth polished condition. There are no hot necks, and mill delays due to bearings are negligible. It is necessary, however, to adjust the thrusts. Bearings are taken out due to the thrust area being badly worn, while the radial section will have ⅛ to 3/16-in. wear at the drive side and approximately 1/16-in. wear on the off-drive side. These bearings now consistently give a life of 900,000 to 1,000,000 tons. Tin babbitt has been tried in these bearings but showed no advantage over lead babbitt. This development was mentioned in a paper presented before the AISE in 1951. It is again mentioned because of its general interest as well as the fact that it is the forerunner of the following development.

The bearing developments of the slabbing mill were carried over to the 46-in. blooming mill (now a 54-in. high lift mill) where alterations were made to suit the needs of this particular mill. This being a "pass" mill, there was more side thrust present than on the other mill, so a high lead bronze thrust was used in place of babbitt. Figure 9 shows a 54-in. blooming mill bearing removed from service with a life of 989,000 tons which is typical for these bearings. The babbitted radial section had ¼ in. of wear. This bearing, as pictured, was returned to service for one more run. The bronze thrust pictured is the third one used for this bearing. There is a 1 3/16 in. clearance between this bronze thrust and the babbitted radial section. This clearance was provided principally to prevent heat being transferred from the bronze to the babbitt. Figure 10 is another view of the 54-in. mill bearing showing the five separate grease connections. The groove for lubricant to the thrust area was placed further into the thrust area than it was for the slabbing mill bearing and in addition,

Figure 9 — A 54-in., blooming mill, bottom bearing shows bronze thrust and grooving.

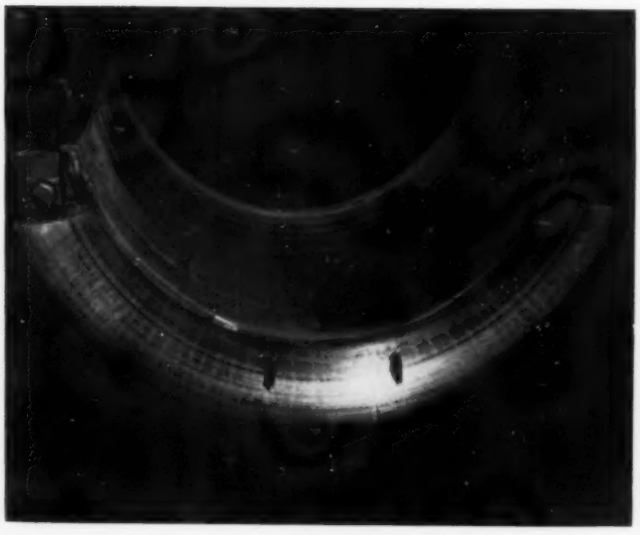
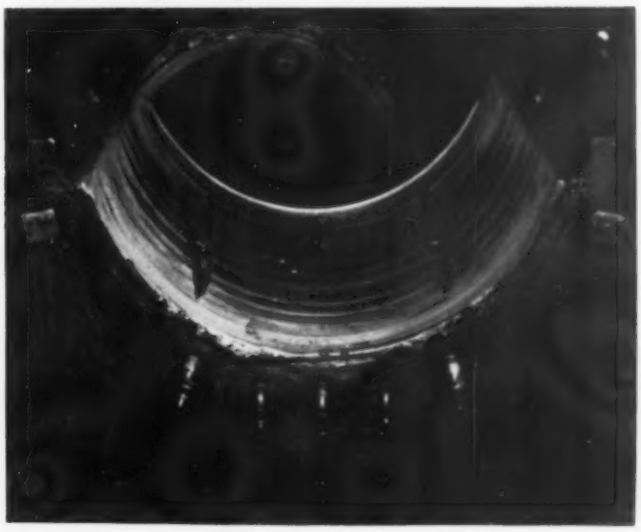


Figure 10 — A 54-in., blooming mill, bottom bearing shows the five separate grease feed lines.



another groove was added for the thrust. The radial bearing section contains three grooves, but the center one near the thrust is now located in the dead center of the bearing. This location might, at first, appear to be a violation of good grooving design in that it appears in a section of the bearing that is generally considered the "loaded" area. However, when rolling, the actual loaded area is to either side of the bearing center, this being a reversing mill; and the load would only be concentrated near or on the bearing center when the mill is idling or has stopped.

The general trend of roll neck bearing design for modern mills seems to be toward anti-friction bearings. There are, of course, many existing mills using enclosed, precision type, babbitted journal bearings with excellent results and there will probably be many more in the future. Improvements in bearings for use on many of the existing old and relatively slow mills will possibly be toward fabric bearings with good scale guards or possibly the totally enclosed type. There are however many old mills with babbitted radial bearings and bronze thrusts, both of which are giving good service and from a practical standpoint will be subject to little future development.

It is well to point out that virtually every mill designer, master mechanic, lubrication engineer, etc., have different opinions on bearing materials, oil and grease grooving, lubricants, method of applying lubricants, scale shields and so forth. Rolling mills are quite individualistic in that a design that operates well in one mill, at times, is of no particular advantage in another mill of similar application. The development procedure, which is typical industry wide, generally consists of an addition "here" or a subtraction "there" and, of course, many trials, as indicated in this paper. Details of the actual final design, however, vary greatly even among mills in the same plant. In roll neck bearing design, there seems to be no clear cut formula available to determine which of the many variables to concentrate on in a specific case. Each of the factors is interrelated with one or more of the others, but it is hoped that some of the examples of changes and improvements given in this paper may be of some help to others with similar problems.

DISCUSSION

PRESENTED BY

JOHN H. HITCHCOCK, Chief Mechanical Engineer, Morgan Construction Co., Worcester, Mass.

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

H. J. LeBECK, Sales Engineer, Joseph T. Ryerson & Son, Inc., Glyco-Ryertex Division, Philadelphia, Pa.

R. L. HUMPHREYS, Lubricating Engineer, Bethlehem Steel Co., Sparrows Point, Md.

J. H. Hitchcock: The high starting torque of fabric bearings which Mr. Humphreys cited may very well have been attributable in this instance to circumstances having nothing to do with the bearing material. The rolls in this mill are grooved, and it is necessary that the grooves in the top and bottom rolls be properly alined with each other. For this purpose it is essential that the rolls be held in a fixed position axially. With the open type bearings originally installed, it was necessary for this reason to force the bearing at each end of the roll in toward the roll barrel, imposing a genuine thrust load and a braking effect even before the mill went into operation. When a double acting outboard thrust bearing is substituted, the rolls can be held in position axially without imposing an unnecessary thrust load; this perhaps accounts for the sharp reduction in power consumption after the installation of the outboard thrust bearing.

The same result can be achieved in virtually the same degree by the use of double acting outboard thrust bearing, consisting of a steel thrust collar fixed to the roll neck and rotating between two stationary fabric thrust rings. This has been employed in a number of the mills we have built with fully enclosed phenolic resin bearings.

I take exception to only one comment made by the speaker; namely, the statement that the trend in roll neck bearings is toward antifriction bearings. My contrary view on this subject you may attribute to prejudice, and with some reason. On the other hand, I am sure the facts will substantiate the view that most mills installed during the last twenty years have been equipped with precision flood-lubricated oil film bearings. This is particularly true of mills rolling flat products.

I appreciate Mr. Humphreys' comment regarding the fine performance of the oil film bearings on the No. 2 rod mill at Sparrows Point.

A. E. Cichelli: The recent impregnation of fabric bearings with a solid lubricant, like molybdenum disulphide, makes me wonder if perhaps in the past we did not have a greater percentage of boundary conditions than we ever suspected in unidirectional rolling. In retrospect, if molybdenum disulphide actually improves life and inasmuch as it can only perform under boundary conditions, the theory that water alone is adequate to support the load hydrodynamically seems open to question.

We should like to express a thought regarding the slabbing mill and the 54-in. blooming mill bearings in which a grease groove was located somewhere around the center. As you know, this practice is not found in too many places for fear that it would be disregarding the theory and laws of lubrication. However, in the case of grease as a lubricant, there is a slightly different situation than exists with oil alone. Some recent laboratory investigations indicate that grease does support a load by building up a film pressure like oil, but only if there was a means for keeping grease flowing through the bearing continuously. In the conventional grease lubricated bearing, however, grease enters the bearing in intermittent pulsations. Apparently then, these bearings are lubricated hydrodynamically at intervals, but in the intervening time, they are operating in the boundary zone of lubrication. Since boundary lubrication predominates, I suspect that this fact is the reason a groove in the load zone does not have the expected adverse effect on the life of the bearing.

As a matter of fact, in this particular instance, the forerunner to this bearing did not have a groove in the center, actually wearing down at this point. By the

introduction of this small groove, grease was introduced to the point of maximum wear. Though there were apprehensions that the groove should not be placed in the load zone, the resulting performance justified the procedure.

All these developments would not have been possible if we were unable to provide foolproof lubrication. There are a number of grease systems on the market, each one requiring different design and maintenance techniques for best performance. One should be familiar with these requirements for each of the different type systems. Once they are understood and one acts accordingly, then "foolproof" lubrication is possible. No matter what system one has, one had better find a way to make it reliable all the time; otherwise, the aforementioned million tons per bearing are out of reach.

H. J. LeBeck: For the record, I would like to say that today, or now, molybdenum disulphide is used in some grades of composition bearings, and then only to the extent of from three to ten per cent, based on the resinous weight. In general, the practice is more frequently closer the three per cent. The resinous weight or the varnish, as it is sometimes called, represents anywhere from forty to fifty per cent of the total bearing weight. As you can see from this, the molybdenum disulphide is a very small, yet very important part of composition bearings.

With regard to the entirely water lubricated bearings, steel men will well remember the years of development of the many features of composition bearings and some of the many mineral fillers that were introduced into the resins to improve bearing life, and above all, to reduce downtime. Mineral fillers, additives or chemical agents have been used for a number of years, in some cases, to neutralize hard water or a chemical reaction in the water. Others were used to assist starting up of mills and sometimes a rather coarse material was used to polish off rust on roll necks after the mill had been down. Mineral fillers were tried to insure against the failure of oiling or lubricating when the mills were down. It was customary to insist that the men lubricate the roll necks on shut downs.

We have found with the introduction of molybdenum disulphide, that a very fine film is being affixed to the roll neck. This film in turn is tending (in many cases) to reduce the coefficient of friction. We have also learned (in many cases) with the addition of this additive, the coefficient of friction of the bearings themselves has been reduced from what it was originally. This has resulted in cases of increased bearing life.

I would like to ask a question with respect to the detail the author showed on the enclosed bearing. I noticed that it showed the grease groove as it is introduced in the chuck, as being right beneath the bearing itself. I am curious to know the width of this groove, and since it is an opening beneath the bearing, if bearing breakage has been encountered at this particular spot in the liners.

R. L. Humphreys: The grease groove, to which Mr. LeBeck referred, is located in the center of the bottom bearings. This groove is ½ in. deep, 1¼ in. wide and extends radially about 40 degrees on each side of the 15/16 in. drilled grease inlet hole. This installation has only been in operation since January 31 of this year, but to date we have had no bearing difficulties. Although this bearing is shown with grease grooving and 0.1 cu in. of grease now goes to each bearing every fifteen minutes, it is hoped someday to entirely eliminate the use of grease on this installation.

A. E. Cichelli: I did not refer to a solid molybdenum disulphide bearing. I believe I mentioned impregnation. What the percentage was I did not know. Granted that it is low, the fact that these bearings seem to work two and three times as long, leads me to conclude that the underlying reason is the presence of the molybdenum disulphide which does no good except under boundary conditions. Certainly there must be times when the bearing is working under hydrodynamic conditions with water, but equally as certain there must be many times when it is in the boundary zone and the water lubricant film is not doing too well. I am not trying to deny the theory that these bearings are lubricated by water. I merely say I do not think a water film alone is adequate to carry the load in many instances — such as the case reported. Water of course is essential in its prime role of coolant, but when a solid lubricant can extend the life of a fabric bearing, the water film just was not adequate to prevent boundary conditions from occurring.

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By C. R. SCHMITT, Manager, Lubrication Sales, E. F. Houghton and Co., Philadelphia, Pa.

Non-Flammable Fluids as applied to the steel industry

. . . . non-flammable fluids are different chemically from petroleum hydraulic oils . . . . the heavier mass gives different flow and turbulence characteristics . . . . before use, an operator should make sure machine is in good condition . . . .

▲ FOR years man has been patiently exploring the secrets of nature in an attempt to improve upon her products. The petroleum industry has been no exception in this respect, having contributed much by way of the development of many synthetic materials. These materials, either used by themselves or in combination with petroleum oils, have made possible the great strides taken in the last quarter century in the development of mechanized equipment.

The breath-taking speed of the modern jet airplane, the performance of today's internal combustion engine, the wonders of electronics and communication systems, — all these and many more symbols of twentieth century progress depend, to a great extent, on these synthetic lubricants for their operation.

The steel industry has benefited much by such developments, in that designers of machinery have utilized these synthetics in electrical and hydraulic systems, resulting in the quantity and quality of today's production.

It is the hydraulic aspect of this picture that we are concerned with. Petroleum hydraulic oils have received continuous attention by research chemists for the past fifteen years. Today's hydraulic oils are made from stocks refined by latest methods to give them utmost stability. They carry additives to protect against foaming, rust, sludge, gums, varnishing.

They are fortified to give highest protection against pump wear. They can be obtained with additives to reduce changes in viscosity as temperature varies.

They are ideal for the purpose for which they were intended — that is, *almost* ideal. Unfortunately, they are inflammable under normal conditions and can become explosively inflammable under conditions when they are subjected to high pressure and a source of flame or high temperature. This is the hazard which occupies attention today and which many suppliers of fluids are sparing no expense to overcome.

It is against this long history of development and usage of petroleum fluids that we must compare the relatively short history of today's synthetic non-flammable hydraulic fluids.

EXAMPLES OF SUCCESSFUL USAGE IN THE STEEL INDUSTRY

For many years petroleum oils have been used in steelmaking machinery without attracting undue attention insofar as the hazard of fire is concerned. Quenching oils, into which white hot pieces of steel are plunged, only occasionally catch fire.

Large reservoirs of lubricating oil used in circulating systems rarely caused any difficulty in this respect.

High temperature lubricants of petroleum nature, used to lubricate bearings, gears and other portions of equipment exposed to extreme heat, occasionally were known to catch fire, but were controllable since they were normally used in small quantities.

Light consistency greases, from which oil separated in generous quantities, and which were and still are used to lubricate bearings exposed to heat from semi-molten steel, rarely were responsible for loss of life or property due to fire.

However, with the spread of the use of modern equipment utilizing hydraulic power in which oil is used as the hydraulic medium, the picture has changed drastically. Inflammable fluid confined in pipes or cylinders under extremely high pressures presents infinitely higher possibilities of fire damage. A petroleum oil bursting from a small crack in a pipe under pressure of a thousand psi and striking a source of extreme heat or flame can engulf a large area with a blanket of fire in a matter of seconds.

Not only does this occur but it is sometimes impossible or extremely difficult to shut off the flow of high pressure oil. Thus instead of a relatively confined fire as would be the case where a reservoir of oil ignites, a raging flame thrower leaps into being, endangering lives and damaging buildings and equipment over a considerable area.

Figure 1 — This electric furnace utilizes hydraulic power for tilting during pouring. Some furnaces also actuate the electrode hydraulically. Fire resistant fluid is in use in such equipment.

For this reason safety engineers and personnel responsible for uninterrupted production in the steel mill have turned to the use of these new non-flammable fluids.

For example, one of the many applications is that of coke oven door machinery actuated hydraulically. Two sources of danger are present here, one being that caused by possible line breakage and spraying of fluid onto hot oven surfaces or incandescent coke. The second hazard arises from possibility of gradual leakage of fluid saturating coal dust surrounding the oven, where it might be ignited by the hot coke dropping out of the oven during discharge.

Many successful examples of hydraulic equipment involving the use of precision pumps are on record using non-flammable fluid. It should be remembered that this is not the most ideal type of application, insofar as cleanliness and outside contamination are concerned. The fact that successful operation has been maintained speaks well of these new fluids. Electric furnaces, where hydraulic mechanisms are used to tilt the furnace and also to actuate the lid, are now successfully served by non-flammable fluids. Pressures of 800 to 1000 psi are commonplace.

Furnace floor chargers, powered by hydraulic systems where pressures of 2500 psi are generated by radial piston pumps, are now operating satisfactorily.

Downcoilers on 76-in. hot strip mills have hydraulic systems operating successfully on non-flammable fluids. Here the hazard lies in possible line breakage and contact of fluid with hot strip steel.

The hydraulic ladle stopper is an example of a modern hydraulic circuit exposed to fire hazard.

Dolomite throwing machines, employing the use of vane pumps and hydraulic motors at pressures of a thousand psi, are now operating in safety with non-flammable fluids.

The coupling tightener machine, employing hydraulic circuits, is still another application for non-flammable fluids in steel plants.

These and many other examples of equipment using hydraulic circuits exposed to high temperatures illustrate the growing acceptance of the non-flammable fluid in today's steel mill.

Doubtless there still are places where applications exist but which have not yet been recognized as being hazardous. As time progresses the list will lengthen and dangers from the explosive force of flaming high pressure oil will diminish in proportion to the extent of usage of the modern fire resistant hydraulic fluid.

FLUIDS

Generally, acceptable fluids of the water base type consist of water, a glycol type thickener, and anti-freeze compound, rust and corrosion inhibitors and additives to impart lubricity and anti-wear qualities. Because of their high water content, they are natural fire resistant fluids.

In addition to these, work is being undertaken by certain suppliers to perfect water-emulsion fluids. These do not fall into the classification of thickened water-base fluids in the same sense as the glycol types.

Not much is known as yet about their performance or properties.

Non-water base fluids now commercially marketed fall into the following chemical categories:

1. Phosphate esters
2. Chlorinated biphenyls
3. Blends of each.

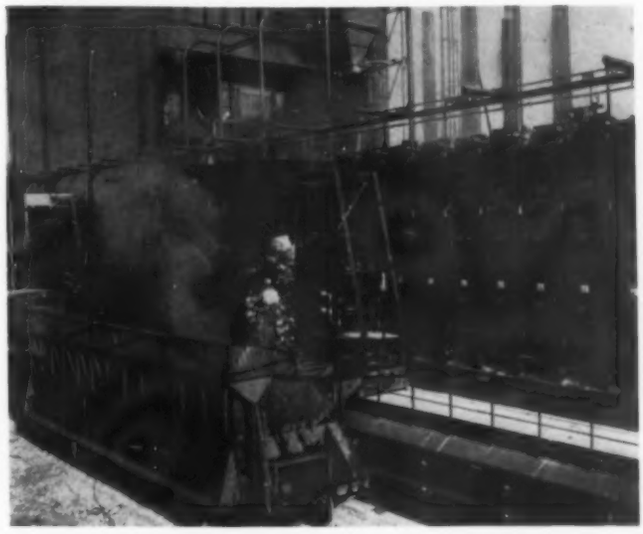
These fluids depend for their fire resistance on the high percentage of chlorene and phosphorus-containing compounds in their molecular structure.

In both water-base and non-water base types, the term "non-flammable" is a relative one. Nearly any substance will burn if subjected to the right conditions. Perhaps a more apt description for the entire group would be "fire resistant" fluids. This is the term used by insurance companies who have tested them and approved their use under hazardous conditions.

Today's fire resistant fluids, because they have different chemical and physical properties from petroleum fluids, should be evaluated with that fact in mind.

First of all, they are superior as far as oxidation characteristics are concerned. They do not break down to form sludges and petroleum gums which interfere

Figure 2 — Fire resistant fluid is used in coke oven door machines where hazards are present due to hydraulic pressure lines adjacent to incandescent coke.



with the proper functioning of valves, pump parts, controls, etc.

With some exceptions, they possess excellent viscosity-temperature characteristics. This means that they can be used over a range of temperatures without thinning out or thickening up excessively.

They do not carbonize under temperatures normally encountered as do petroleum oils.

Fluids of the water base type, having a high specific heat and high thermal conductivity, maintain lower fluid temperatures than do petroleum oils and effect a savings in cooling water costs.

On the other hand, these fluids have higher specific gravity and, because of this greater mass, things occur under high velocity flow which are not completely understood. This is an especially important factor as regards the suction side of hydraulic pumps where a change in the nature of the fluid flow can produce mechanical effects which occasionally are mistakenly diagnosed. For example, statements made concerning non-flammable fluids sometimes refer to their inferiority to petroleum oils insofar as protection against wear in pumps is concerned. This is under careful study now and evidence is being gathered which may throw an entirely new light on the subject.

Using the same tests which have been designed to determine the lubricating value of petroleum oils we find that non-flammable fluids are capable of withstanding equal and in some cases, higher loads than oils of similar viscosity. Tests which have been run on the Falex, Almen and Cornell film strength machines substantiate this fact.

In other tests run on full-scale pumping equipment, a manufacturer of hydraulic pumps found that a particular brand of non-flammable fluid protected the heavily loaded bronze sleeve bearing whereas the conventional hydraulic oil did not have sufficient lubricity to do so. Prior to this, it was necessary to employ a needle bearing where petroleum fluid was used. In the face of these facts let us consider the complaints which have been registered in some cases of deterioration of pumping surfaces, particularly rings of vane type pumps. Usually, when such complaints are investigated, it is found that ring surfaces are either scored or have chatter marks running cross wise on the ring surface. This problem is being studied carefully and to date, this type of failure cannot be explained satisfactorily on the basis of lack of lubricity. While all of the data is not yet compiled, it appears that the majority of bona-fide complaints arise where pumps are operating at the peak of volumetric capacity, or where intake screens clog due to some form of contamination.

In these relatively few cases where complaints have been registered, the pumps in question are those which normally operate on the border line of starvation. Anything which would interfere with sufficient intake fluid to fully satisfy pumping requirements could, under such circumstances, result in violent fluid shock waves. The subsequent damage due to vibration of the vanes resulting in chatter marks and gouging of the ring. This can easily be demonstrated by placing the fingers across the intake pipe opening below the surface of the fluid while the pump is operating. Depending upon the amount of fluid restriction, a violent vibration can be set up which, if continued for an extended period, could result in failure of the pump.

Another possible factor in such cases which has not been given much publicity is turbulence. It is a well known fact to hydraulic engineers that turbulent flow in pipes can result in astonishing fluid effects. Much work has been done to determine properties of fluids which cause turbulence in the pressure side of hydraulic systems.

An equation used to determine the possibility of turbulence of fluids is that having to do with the determination of Reynolds number. This is a non-dimensional quantity which is the criterion of whether flow is laminar or turbulent. When the Reynolds number reaches a so-called "critical value," flow changes from laminar to turbulent. For example, one well known hydraulic engineer, working with full scale industrial equipment, has determined from actual tests that when the Reynolds number exceeds 2200, fluid temperatures rise, vibrations are set up, pump wear increases and, in general, the system deteriorates.

Figure 3 — This shows test setup to demonstrate the manner in which petroleum hydraulic oil under pressure bursts into flame when passed through a torch.

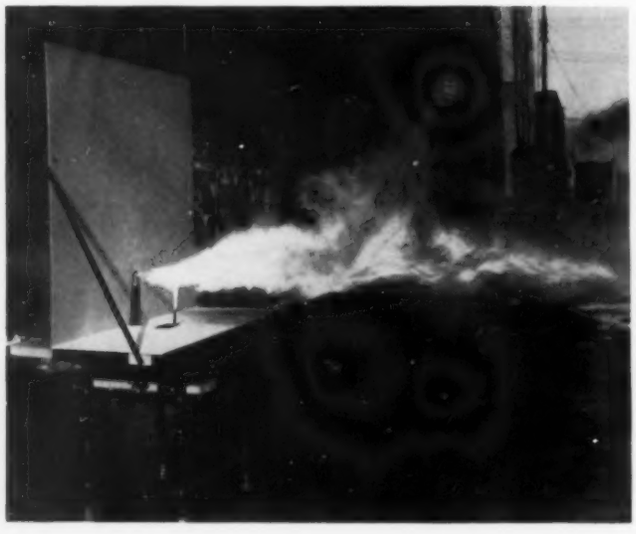


Figure 4 — This is the same test setup as that shown in Figure 3 except that fire resistant fluid is used. Note that torch flame is bent over from force of spray but no burning of fluid occurs.

One of the factors which is directly proportional to the Reynolds number is specific gravity. The higher the specific gravity (weight per unit of volume) the higher is the Reynolds number. Therefore, since non-flammable fluids have considerably higher specific gravities than petroleum oil, it is not difficult to see why turbulent effects may, under certain critical conditions, be obtained with their usage.

Another factor which is of importance is that of pipe size. The larger the pipe, the lower will be Reynolds number, and the probability of turbulence will be reduced. For this reason, it is advisable at times to place a larger size pipe on the intake side of the pump than that used for petroleum oils.

Very little actual study has been made of the effect of Reynolds number on fluids flowing in the *suction* side of hydraulic circuits. One authority on this subject, however, in working with non-flammable fluids has reached some conclusions which, of course, are still tentative. It is his observation that the value of the Reynolds number should not exceed 325 for high specific gravity fluids in intake piping and pump openings. This may require a revision in design thinking on the part of the pump manufacturer, since some of the more critical pump sizes may have to be relieved in the fluid intake parts.

Before leaving this subject, it is well to note that intake filters located on the suction line should be carefully examined to make certain that they have a large capacity so as to provide ample flow of intake fluid.

Considerable time has been spent in covering this cause and effects of turbulence in intake piping. We feel that it is the one point of investigation so necessary to the final assurance of successful use of modern non-flammable fluids. When this subject has been thoroughly explored and corrections made, we may see overall performances by some of these fluids which will exceed even the finest petroleum oils.

CONSIDERATIONS PRIOR TO INSTALLATION OF NON-FLAMMABLE FLUIDS

Obviously, the reason these safety fluids are used, is because of the presence of conditions which create a fire hazard. However, the fluid used not only must possess resistance of flammability but must be able to protect the expensive equipment in which it is placed. Thus, it places a burden upon the user as well as the supplier to make certain that the conditions present in the equipment are such that maximum efficiency can be obtained from the fluid.

First, the supplier must be acquainted with the type of pump and the pressure at which it is expected to operate.

Next, the machine should be inspected for an estimate as to its cleanliness and whether or not its reservoir has been painted with a coating which would be removed by the fluids.

Another consideration is the temperature to which the fluid will be exposed and an estimate of what the bulk temperature will be during service.

The supplier of the fluid should be consulted for advice as to compatability of the fluid with packings and seals presently installed in the machine.

Finally it is well to check on the performance of the

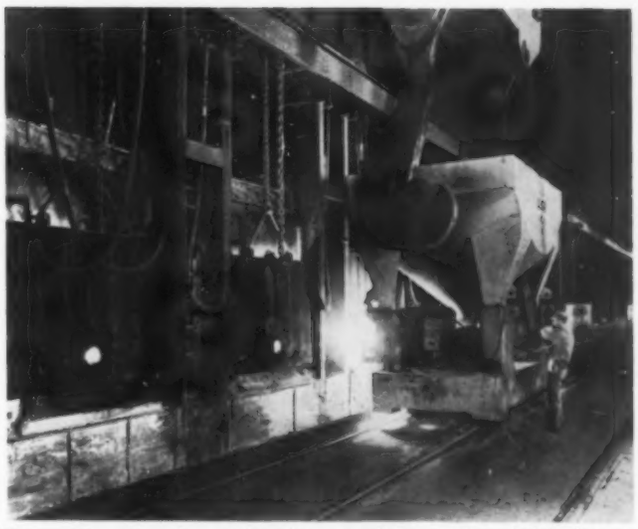


Figure 5 — In the dolomite machine, the dolomite is thrown into the furnace hearth by means of an endless belt actuated by a hydraulic motor. Fire resistant fluid is used to eliminate possible ignition of petroleum oil under pressure should a line burst.

fluid in equipment similar to that which is being considered.

Care should be used to prepare the machine prior to the installation of the non-flammable fluid. The supplier of the fluid should be consulted for his recommendation in this respect. Removal of oxidized oil sludges, gums and varnish deposited throughout the hydraulic system by the oil previously used, will permit the incoming fluid to perform its job in the most satisfactory manner.

Such precautions have been recommended for years when changing petroleum oil systems, particularly when changing from one type of oil to another. Therefore, the same approach should be applied when non-flammable fluids are first installed.

In some cases, light flushing oils or conventional cleaning compounds may be used with completely

Figure 6 — This piece of hydraulic tubing burst under pressure. The fluid escaping from such an opening could, if inflammable, ignite near a source of heat and cause damage to life and property.

satisfactory results. In other cases it may be advisable to use flushing concentrate prior to the use of water base fluids.

Careful flushing is particularly advisable when changing from one non-flammable fluid to another.

A word of caution is in order here against mixture of one non-flammable fluid with another. This is true whether they be water base or non-water base fluids. Some users have felt that, particularly where water base fluids are concerned, no great harm can come from mixing. This is an erroneous attitude, since usually the only constituent common to such fluids is the water and even this may be different in nature. Here again, it is essential that the supplier of the fluid be consulted for his opinion in the particular circumstance.

At intervals, the user is confronted with the problem of removing paint from the reservoir. Some manufacturers of machine tools paint the interior of reservoirs for various reasons, chief among which is to protect against rusting during idle periods. Also, condensation of moisture from surrounding atmosphere, particularly under high conditions of humidity, might cause rust above the liquid level.

One method of accomplishing this is to apply paint remover to surfaces wetted by the fluid and manually removed by scraping. Where this was not possible in one instance, a large user developed a method of adding a concentrated caustic to the reservoir. This caustic was added in the amount of ten gallons to a 180-gal reservoir, or about 5 per cent of capacity. A steam jet kept the solution agitated and the hot condensate built up the liquid level.

This hot caustic solution was then permitted to set for several hours until the paint was dissolved or stripped from the surface. The reservoir was drained and followed by a high pressure jet washdown to remove remaining particles still clinging to the surface.

Water was then introduced and drained several times until the caustic was fully neutralized. This was checked by testing the rinse water with litmus or pH paper.

Following clean up and installation of the non-flammable fluid, a check should be made to see that fittings and joints are tight, particular care should be taken to see that no air leaks exist in the suction line leading to the pump.

The user of course, is in a position to know the mechanical condition of the pump to be used. Sometimes, however, because of press of production schedules or lack of time, the pump is presumed to be in good mechanical condition. Often, such is not the case, and the pump may soon need mechanical attention. When the new fiuid is placed in service, certain stresses are present due to entrapped air in the lines. Because of abnormal pressure surges, the worn pump parts break down under the strain.

This has occurred on occasion in the writer's experience, and fortunately proof was available that the new fluid was not at fault. When the pump was overhauled and again placed in service, it continued to operate satisfactorily.

In particular, seals and gaskets, which have the duty of preventing air leaks, should be inspected and replaced if necessary.

In starting the machine initially, the relief valve should be set at a low pressure and the pump eased in so that air in the lines is expelled and fluid in sufficient volume fills the lines to provide adequate protection to the pump.

These precautions are emphasized by the author simply to underline the fact that the new fluids are non-petroleum. They have different mass and weight characteristics, and therefore, should not be treated in exactly the same manner as petroleum hydraulic oils.

Lastly, it is well to remove a sample of the fluid shortly following initial run-in so that it might be checked by the supplier's laboratory to make certain that it is in satisfactory condition.

SUMMARY

It may appear, from the comments made in this paper regarding properties of non-flammable fluids and the precautions to be taken during their use, that they are tempermental. This was not the author's intention, but rather it was felt necessary to emphasize the proper procedures developed through experience, so that the prospective user could proceed without difficulty.

The non-flammable fluids are chemically different from the familiar petroleum hydraulic oil. Because of the heavier mass they have somewhat different flow characteristics and thus behave differently from oil when the system is improperly engineered or carelessly assembled. For this reason, in order to take advantage of them as hydraulic fluids, it is desirable to make certain that the machine is in reasonably good condition.

It has been the author's good fortune to be active during the development of petroleum hydraulic fluids from their position fifteen years ago to the present.

During that period, and particularly in the early stages, volumes were written and spoken in an effort to educate industry as to proper methods for using them. It was only after constant pressure through technical societies, trade journals, advertising, product bulletins, etc., that the "do's" and "don'ts" of hydraulic oil usage became firmly established. Today, procedures for usage of petroleum hydraulic oils are so well established that they are regarded as routine. Troubles with sticky hydraulic valves, corrosion of system metals, sludge, varnish, packing attack, etc., so prevalent earlier with petroleum oils, are now seldom encountered.

A similar situation exists today with the increasing use of non-flammable fluids. Certain "growing pains" are being suffered but experience and education are providing the antidotes to ease the discomfort.

As time passes, and routine maintenance procedures are established and adhered to, such difficulties will diminish to the point where they, too, will be part of the dim past.

Today, therefore, a similar task faces the user, the machine and pump builder and the supplier of hydraulic fluids. The user should realize that certain steps must be taken to get the most good from the non-flammable fluids. Manufacturers of pumps and other component parts may have to revise their thinking as regards design of such mechanisms when they are applied to machinery using non-flammable fluids. The supplier of non-flammable fluids must take steps to make all information concerning the properties of his fluid available. In addition, he must not relax in his efforts to learn by experience and constantly improve his product as such experience dictates.

DISCUSSION

PRESENTED BY

MERRITT A. BIGELOW, JR., Special Products Dept., Carbide and Carbon Chemicals Co., Chicago, Ill.

JOSEPH S. AARONS, Lubricants Chemist, National Tube Division, United States Steel Corp., Pittsburgh, Pa.

C. R. SCHMITT, Manager, National Lubrication Sales, E. F. Houghton and Co., Philadelphia, Pa.

GEORGE G. SPEHN, Assistant Manager, D. A. Stuart Oil Co., Ltd., Detroit, Mich.

M. A. Bigelow, Jr.: We are gratified to note the interest in aqueous-base, hydrolube-type, fire-resistant hydraulic fluids, particularly since our company pioneered the development of this type of fluid for industrial use about eight years ago. Our comments will be restricted to aqueous-base fluids of the hydrolube type.

Actually, aqueous-base fluids are neither new nor unusual to the steel industry. They have been used successfully in hydraulically actuated combustion-control regulators for the past five years. Pressures of 200 psi are generally encountered in these systems. Some vapor-phase corrosion of the regulator housing and component parts has been encountered with regulators handling coke oven gas of a high sulphur content. This problem has been solved in many instances through the use of double-stuffing boxes with atmospheric vents. Another related application is the use of these fluids in hydraulically actuated reversing systems for soaking pits. Leakage and line ruptures near the soaking pits present an obvious fire hazard. Billet separators and crop shears are also being successfully operated at pressures of 1000 psi with aqueous-base fluids.

Field service experience and laboratory tests show that aqueous-base fluids can be used satisfactorily in most conventional hydraulic systems. Aqueous-base fluids have given satisfactory pump life and excellent performance characteristics when tested in a commercial vane pump for 750 hours of operation at a continuous pressure of 1000 psi and a bulk fluid temperature of 150 F. In these tests, wear losses of pump parts were found to be comparable with those obtained with a widely-used petroleum hydraulic oil operating under the same conditions. Fluid delivery was maintained at a consistently higher level with the aqueous-base fluids. Numerous commercial installations operating over a period of years have indicated that, with proper attention to hydraulic system maintenance, replacement of pump parts is not significantly higher with aqueous-base fluids than with standard petroleum oils.

The effect of the aqueous-base fluids on seals and packings deserves some amplification. The swelling effect from these fluids is of a very low order with all types of rubber seals. Typical linear swell values in 5-day immersion tests at 158 F range from 0 to 2 per cent for natural, neoprene, buna, butyl and silastic rubbers. None of these are considered to be excessive and it may be concluded that no special seals are required.

The theoretical considerations pertaining to turbulence that have been raised by Mr. Schmitt are very interesting, but it should be pointed out that this is a controversial subject and one on which several pump manufacturers disagree. Reynolds number is considered to be strictly applicable only when considering flow through straight pipes. Our field experience indicates that the few cases of reported high pump wear are usually traced to filter clogging with resulting pump starvation and cavitation. Filter clogging may be caused by dirt, paint, petroleum oil sludge, and grease. Many types of pumps are provided with an external grease fitting for bearing lubrication. The natural tendency is to overgrease this bearing. Grease eventually finds its way into the pump housing and is carried to the reservoir by slippage fluid. Since conventional petroleum oil greases are not compatible with the aqueous-base fire-resistant fluids, the grease becomes dispersed or emulsified and eventually appears on the fluid surface and/or the intake line strainer or filter as a mucilage-like sludge. If petroleum hydraulic oils were used in the same system, this situation would not exist since petroleum oils are compatible with the grease. This problem can be minimized by lubricating the pump bearings every two to three months rather than daily or weekly, as is common practice. The use of a lithium-base soap grease that is quite water-insoluble will also help to eliminate this problem.

It is a perfectly natural tendency to blame a new product when trouble appears where it did not previously exist. Actually the real trouble may be caused by inadequate maintenance or failure to follow the trouble-shooting practices commonly recommended for petroleum hydraulic oils.

In conclusion, we wish to emphasize that the user or prospective user of fire-resistant fluids should be certain that all maintenance personnel involved are thoroughly educated in the use and handling of these fluids by the supplier. A round-table discussion conducted by the supplier will often prove quite successful in initiating this educational program.

Joseph S. Aarons: Would you care to comment on your pump test at your laboratory? Would you tell me the speed of your shaft?

C. R. Schmitt: This is a vane type pump testing setup utilizing methods for varying pressure and temperature. The present pump shaft speed is 1200 rpm.

The question was also raised as to our experience in vane-type pumps. Our principal laboratory testing has taken place using this type and these tests have been progressing for more than three years.

In the field, our experience, again, has mainly been in vane pumps although users of the fluid have placed it in other pump designs. It is still too early to state what types, in general, will be suitable.

Where trouble has been encountered in industrial applications, it has generally been traced to improper preparation of the machine or restriction of the intake lines to the pump. This is particularly true where pumps are operating at the limit of their rated capacity.

George G. Spehn: I want to ask a question in regard to drop in viscosity. When the water content decreases, would not the viscosity increase as you lose the water?

C. R. Schmitt: Normally, yes. When the water content decreases the fluid will increase in viscosity. In rare instances there may be contaminating diluents which might counteract the loss of water and result in little or no increase in the viscosity of the bulk fluid.

Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1955 CONVENTION

HOTEL SHERMAN

CHICAGO, ILLINOIS

September 26, 27, 28 and 29

Monday, September 26

9:00 am — REGISTRATION — Old Chicago Room

9:15 am — BUSINESS MEETING — Louis XVI Room

Conducted by President John H. Vohr

9:30 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: R. J. Beeswy, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.
A. J. F. MacQueen, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

"Improved Mill Performance Through Modernized Electrical Control," by E. B. Fitzgerald, Assistant Division Manager, Industrial Control Sales, and Eric Pell, Engineering Supervisor, Cutler-Hammer Inc., Milwaukee, Wis.

"Power Requirements and Selection of Electric Equipment for Hot Strip Mills," by R. E. Marrs, Steel Mill Application Engineer, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Tonnage Heating by Induction," by R. S. Segsworth, Director of Research, The General Engineering Co., Ltd., Toronto, Canada, and M. C. D. Hobbs, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada

9:30 am — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: Robert Sergeson, Chief Metallurgical Engineer, Rotary Electric Steel Co., Detroit, Mich.
F. E. Robinson, Assistant Division Engineer, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio

"Layout and Design of Ingot Mold Foundries," by Glenn W. Merrefield, Foundry Engineer, Giffels and Vallet, Inc., Detroit, Mich.

"The Effect of Finishing Temperature on the Properties of Hot Rolled Steel Plate," by R. H. Frazier, F. W. Boulger, Assistant Chief and Chief, Division of Ferrous Metallurgy, and C. H. Lorig, Technical Director, Physical and Process Metallurgy, Battelle Memorial Institute, Columbus, Ohio

"Hot Extrusion of Carbon Steel Solid Sections," by Joseph K. Seyler, Superintendent, Hazelwood Cold Finishing Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

2:00 pm — COMBUSTION SESSION — Louis XVI Room

Chairmen: F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.
F. C. McGough, Superintendent Power and Fuel, Detroit Steel Corp., Portsmouth, Ohio

"Balanced Pressure Coke Oven Gas Distribution," by H. V. Flagg, Combustion Engineer, Armco Steel Corp., Middletown, Ohio

"Local and Interplant Gas Dispatching in Steel Plants," by H. J. Rohm, General Coordinator, Fuel and Power, United States Steel Corp., Pittsburgh, Pa.

"Experiences in Purging Plants and Mains," by Hugh E. Ferguson, Chief Testing Engineer, The Peoples Gas Light and Coke Co., Chicago, Ill.

2:00 pm — ROLLING MILL SESSION — Crystal Room

Chairmen: George A. Henderson, Superintendent Rolling Mill Div., Bethlehem Steel Co., Lackawanna, N. Y.
R. C. Schaefer, Superintendent Hot Strip Mill, Wheeling Steel Corp., Steubenville, Ohio

"The Use of the Modern Assel Mill in the Production of Seamless Steel Tubing," by Charles E. Snee, General Foreman, Assel Mill, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

"Modernization of the Hot and Cold Continuous Strip Mills, Bethlehem Steel Co. — Lackawanna Plant," by F. S. Eckhardt, Chief Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

"Rolling of Thin Strip, Part II," by M. D. Stone, Manager Research and Development, United Engineering and Foundry Co., Pittsburgh, Pa.

Tuesday, September 27

9:00 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: Ray T. Winterringer, Assistant Superintendent, Electrical Dept., Republic Steel Corp., Chicago, Ill.
F. H. Wickline, Electrical Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

"Integrated Electro-Mechanical Press Puller Drive System Improves Extrusion Quality," by R. C. Suttle, Application Engineer, Metals Div., Reliance Electric and Engineering Co., Cleveland, Ohio

"Contributions to Arc Furnace Operations," by L. A. Wynd, Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.

"Increasing Capacity of Ladle Cranes," by Eugene Whitaker, Mechanical Engineer, Granite City Steel Co., Granite City, Ill.

"Report on Standardization of Additional AISE Mill Motor Frames," by M. B. Antrim, Chairman, Mill Motor Committee, and Assistant Manager, Maintenance and Construction, Lukens Steel Co., Coatesville, Pa.

9:00 am — MECHANICAL SESSION — Crystal Room

Chairmen: J. B. Whitlock, General Maintenance Engineer — All Plants, Armco Steel Corp., Middletown, Ohio

C. W. Bruce, Chief Engineer, Republic Steel Corp., Chicago, Ill.

"Welded Structures as Applied to Cranes and Mill Equipment," by I. W. Evans, Chief Welding Engineer, Morgan Engineering Co., Alliance, Ohio

"Ideal Maintenance Machine Shop Facilities," by W. J. Pearson, Machine Tool Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Protective Coal Tar Coatings in Steel Plants," by Dr. W. F. Fair, Jr., Coatings Consultant, Tar Products Div., Technical Dept., and H. J. Cibula, Sales Representative, Tar Products Div., Sales Dept., Koppers Co., Inc., Pittsburgh, Pa.

2:00 pm — COMBUSTION SESSION — Crystal Room

Chairmen: F. Bruce Bevelheimer, Power and Fuel Engineer, Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich.
George J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.

"Fans For Iron and Steel Mills," by Robert Jorgensen, Assistant Chief Engineer, Buffalo Forge Co., Buffalo, N. Y.

"Developments in Steam Generation for Steel Plants," by F. X. Gilg, Executive Assistant, and Norman W. Young, Assistant Chief Staff Engineer, Boiler Div., The Babcock and Wilcox Co. New York, N. Y.

"Steam-Fuel Ratio Control as Applied to Open Hearth Furnace Operation," by W. H. Kahl, Combustion Engineer, Open Hearths, Inland Steel Co., East Chicago, Ind.

2:00 pm — OPERATING PRACTICE SESSION — Louis XVI Room

Chairmen: George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

George I. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"Normalizing and Quench-and-Temper Heat Treatment of Steel Products," by James MacGregor, Board Chairman, York-Gillespie Manufacturing Co., Pittsburgh, Pa.

"Increased Steel Production From Desiliconized Hot Metal," by E. C. Wright, Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.

"Oxygen Steel in United States," by C. R. Austin, Manager, Oxygen Steel Div., Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

6:00 pm — OLD TIMERS DINNER — Louis XVI Room

Wednesday, September 28

9:00 am — BLAST FURNACE SESSION — Louis XVI Room

Chairmen: James A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

C. G. Hogberg, Assistant to Vice President, Michigan Limestone Div., United States Steel Corp., Detroit, Mich.

"Recent Developments in Sintering and Pelletizing," by Edwin N. Hower, Manager, and John A. Anthes, Process Engineer, Industrial Dept., Dravo Corp., Pittsburgh, Pa.

"The Installation Of, and Split Wind Blowing With, Topping Turbo Blowers for Blast Furnaces," by E. O. Austermiller, Chief Engineer, and W. A. Smith, Superintendent, Power and Fuel Dept., National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

"Underhearth Cooling of the Bottom of Blast Furnaces: Temperature Distribution and Heat Extraction," by Victor Paschkis, Technical Director, and Taghi Mirsepassi, Research Assistant, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: D. N. Evans, Assistant Superintendent, Field Forces Dept., Inland Steel Co., East Chicago, Ind.

E. T. W. Bailey, Chief Combustion Engineer, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

"Factors in Solvent Selection and Control of Hazards in the Steel Industry," by John B. Moore, Technical Director, John B. Moore Corp., Nutley, N. J.

"Additives in Steel Mill Lubricants," by M. S. Clark, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

"Selection of a Lubricant for Cold Drawing,"
Part I **"Coarse Steel Wire,"** by Bruce W. Siemon, Standard Industrial Compounds Co., Chicago, Ill.

Part II **"Fine Steel Wire,"** by W. B. Bauzenberger, Sales Manager, Apex Alkali Products Co., Philadelphia, Pa.

2:00 pm — COMBUSTION SESSION — Louis XVI Room

Chairmen: G. H. Krapf, Division Superintendent of Utilities, South Works, United States Steel Corp., Chicago, Ill.

R. A. Lambert, Superintendent Steam and Combustion, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"The Continuous Annealing of Tin Plate Strip," by Horace Drever, President, Drever Co., Bethayres, Pa.

"Heating Heavy Sections — How Fast?," by Quentin Bloom, Project Engineer, Selas Corporation of America, Philadelphia, Pa.

"Electric Open Hearth Combustion Control at Algoma," by A. K. Bayles, Chemical Engineer, and D. H. Stanton, Fuel Engineer, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

2:00 PM — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: Robert W. Holman, Assistant Vice President, Research and Technology Div., United States Steel Corp., Pittsburgh, Pa.

M. D. Ayers, Chief Engineer, Wheeling Steel Corp., Wheeling, W. Va.

"Electrostatic Application of Materials in the Steel Industry," by Dr. Emery P. Miller, Director of Research and Development, Ransburg Electro-Coating Corp., Indianapolis, Ind.

"The Practical Approach to Coil Splicing," by R. E. Morton, Vice President and General Manager, Morton Manufacturing Co., Muskegon Heights, Mich.

"Developments in Scalebreaking and Continuous Pickling Lines," by J. I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

7:00 pm — FORMAL DINNER — Ball Room

10:00 pm — DANCE — Ball Room

Thursday, September 29

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: D. C. Whitehead, General Lubrication Engineer, Crucible Steel Company of America, Pittsburgh, Pa.

Charles T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

"Lubrication—Systems and Applications at Fairless Works," by W. E. Rigot, Lubrication Engineer, United States Steel Corp., Fairless Hills, Pa.

"A Practical Approach to a Fuel and Lubrication Problem," by C. R. Burton, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Div., United States Steel Corp., Hibbing, Minn.

"Oil Mist Lubrication and Some of Its Applications in the Steel Industry," by T. M. Murphy, Manager Industrial Sales, Alemite Div., Stewart-Warner Corp., Chicago, Ill.

9:00 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: D. C. McCrady, Superintendent Electrical Dept., The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

Richard G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Rectifier Equipment to Supply D-C Power in Steel Mills," by C. S. Hague, Manager, Power Conversion Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Modernization of an Industrial Plant Power Distribution System," by A. C. Stoever, Superintendent of Utilities, Granite City Steel Co., Granite City, Ill.

"Distribution of Power in a Modern Cold Mill," by E. A. Young, Superintendent of Maintenance, Sheet and Tin Mills, Indiana Harbor Works, Youngstown Sheet and Tube Co., East Chicago, Ind., Frank Nolan, Switchgear Engineer, and A. D. Millikin, Rectifier Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

1:00 pm — INSPECTION TRIP TO INDIANA HARBOR WORKS, YOUNGSTOWN SHEET AND TUBE CO., EAST CHICAGO, IND.

CONVENTION CHAIRMEN

R. J. BEESWY

A. J. F. MacQUEEN

ROBERT SERGESON

F. E. ROBINSON

F. R. PULLEN

F. C. McGOUGH

G. A. HENDERSON

R. C. SCHAEFER

RAY T. WINTERRINGER

F. H. WICKLINE

J. B. WHITLOCK

C. W. BRUCE

F. B. BEVELHEIMER

G. J. GOCKSTETTER

GEORGE H. GREENE

GEORGE I. BOTTCHER

J. A. BELL

C. G. HOGBERG

D. N. EVANS

E. T. W. BAILEY

G. H. KRAPF

R. A. LAMBERT

R. W. HOLMAN

M. D. AYERS

D. E. WHITEHEAD

C. T. LEWIS

D. C. McCRADY

R. G. NOLAN

ABSTRACTS of TECHNICAL PAPERS

to be presented at technical sessions of

AISE ANNUAL CONVENTION

HOTEL SHERMAN

CHICAGO, ILL.

September 26, 27, 28, 29

"IMPROVED MILL PERFORMANCE THROUGH MODERNIZED ELECTRICAL CONTROL"

by E. B. FITZGERALD, Assistant Division Manager, Industrial Control Sales, and ERIC PELL, Engineering Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

E. B. FITZGERALD

▲ THE history of the steel industry has been marked by a rapid rate of technological advancement in steelmaking methods, processes, and machines. With each new installation of high capacity, high product quality, steelmaking facilities — the steel industry, and its individual operating companies, are faced with the problem of producing a competitive product on equipment that has been installed and operating for many years, and which often does not possess all of the modern features of the new facilities.

Since it is impractical to discard all existing equipment and purchase new facilities to meet the challenge of each new method, process or machine; the steel producers face a continuing problem of maintenance or rejuvenation of older facilities. This paper, therefore, deals with a suggested means of economical modernization of obsolete facilities to attain operational performance comparable to that provided by new equipment.

ERIC PELL

In the specific example, a case history is related in which one steel company, through an intelligent study of the characteristics of its existing blooming mill, was able to plan an economical modernization of the blooming mill's electrical control—and how through this modernization the performance of this blooming mill was improved to the point that the mill could commercially compete with more modern installations.

Through this example, this paper emphasizes how many characteristics of out-moded mill equipment, not ordinarily associated with the equipment's electrical control can be traced to an obsolete type of control, and how these characteristics can be radically improved through a low cost control redesign.

"POWER REQUIREMENTS AND SELECTION OF ELECTRIC EQUIPMENT FOR HOT STRIP MILLS"

by R. E. MARRS, Steel Mill Application Engineer, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

R. E. MARRS

▲ THE selection of main drive electric equipment for a modern quantity and quality production hot strip mill has reached the stage of an exact science. It is becoming more necessary to study each new installation thoroughly to determine the proper choice of equipment and the performance to be obtained.

This paper describes a quick method of determining the power required to roll hot strip based on a convenient form of power curve.

A resume of common drafting practice is given for assistance in selecting a speed cone, or the range in mill stand speeds.

Data is given on the ratings and relative costs of roughing and finishing stand motors to aid in the selection of drive speeds and gear ratios.

A brief discussion is included on power supply con-

version equipment requirements, protective devices, equipment ventilation and trends in control systems.

"TONNAGE HEATING BY INDUCTION"

by R. S. SEGSWORTH, Director of Research, The General Engineering Co. Ltd., Toronto, Canada, and M. C. D. HOBBS, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada

R. S. SEGSWORTH

▲ THIS title has been selected to direct attention to those applications of electrical induction heating where the part is heated throughout, as for forging, extrusion, rolling and through heat treating, and where the sizes and qualities involved justify the use of low and medium frequencies.

Data are given to show the potential field of applications, based primarily on economical considerations, but including reference also to some applications which from a technical point of view, may best be handled by the induction method.

Two typical installations are described, where the low and dual frequency induction heating methods have been applied, and in which many tens of thousands of tons of steel have already been heated.

M. C. D. HOBBS

One application is heating 6-in. square mild steel ingots to forging temperature at the rate of about 4 tons per hour. Cost and performance are given on this operation in comparison with the rotary hearth furnace used previously.

The second example is an ingot heating furnace in a rolling mill. This is at present the largest single induction heating unit in the world, and the paper describes the unit in a general way, refers to some of the problems encountered and gives some operating data which is compared with previous experience, in this case with manually charged fuel-fired batch furnaces.

"LAYOUT AND DESIGN OF INGOT MOLD FOUNDRIES"

by GLENN W. MERREFIELD, Foundry Engineer, Giffels and Vallet, Inc., Detroit, Mich.

▲ MANUFACTURE of ingot molds and stools is a production process and a definite tonnage of these castings is required in most steel operations. This tonnage has a direct relation to the tons of steel ingots to be produced, and can be adjusted as ingot mold life is improved.

The layout and design of modern ingot mold foundries, to produce improved quality ingot mold and stool castings, and to provide pleasant, healthful working conditions for the employees, is discussed in this paper.

G. W. MERREFIELD

The two engineering phases generally used are that of: (1) preliminary survey phase, where the proper layout is determined, together with the cost of the project, cost of operation, manning, etc., to determine the economics of the proposed project by the management, and this is followed by the (2) detail design phase, where all detail specifications are worked out for construction and installation of equipment.

The various divisions of an ingot mold and stool foundry are covered in detail, from the receipt of the materials to the shipment of the finished mold and stool castings. The processes and equipment in some of the modern ingot mold foundries is described in this paper, and a number of slides are used to show some of the equipment installations in these foundries.

"THE EFFECT OF FINISHING TEMPERATURE ON THE PROPERTIES OF HOT ROLLED STEEL PLATE"

by R. H. FRAZIER, F. W. BOULGER, Assistant Chief and Chief, Division of Ferrous Metallurgy, and C. H. LORIG, Technical Director, Physical and Process Metallurgy, Battelle Memorial Institute, Columbus, Ohio

R. H. FRAZIER

▲ MOST of the plain-carbon steel plate manufactured in the United States cannot be heat treated due to the lack of heat-treating facilities. Therefore, it is imperative that the mechanical properties be of the highest quality when the plate leaves the rolling mill. Several mill variables influence the mechanical properties of the hot-rolled plate. The one selected for study in this investigation is the temperature of the plate during the last working pass in the rolling mill.

The temperature of the steel plate was carefully controlled in the laboratory by an equalizing treatment at the desired temperature before the final pass on the rolling mill. It was found that the finishing temperature influenced the ferrite grain size, the yield strength, and the notched-bar transition temperature of the steel plate. The higher finishing temperature produced steels having larger ferrite grains and a lower yield strength for the same tensile strength. The keyhole Charpy test and the

F. W. BOULGER

C. H. LORIG

Navy tear test were used to determine the notched-bar transition temperature. In both tests, a low transition temperature is desirable since it indicates the steel has a better chance to resist brittle failure. On the average, decreasing the finishing temperature 100 F lowered the transition temperature 6 F in the Charpy test and 8 F in the tear test. The influence of finishing temperature was approximately the same for semikilled steels as it was for aluminum-killed steels.

Normalizing commercially-rolled plate at 1650 F lowered the Charpy and tear test transition temperatures of the steels investigated. The beneficial results of normalizing were more pronounced for aluminum-killed steels than for semikilled steels. This difference can be explained by the austenitic grain size of the steel at normalizing temperatures.

"HOT EXTRUSION OF CARBON STEEL SOLID SECTIONS"

by JOSEPH K. SEYLER, Superintendent Hazelwood Cold Finishing Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

J. K. SEYLER

▲ THE steel industry, in its effort to supply better products to its customers, is constantly developing new methods and processes. Such a new process is the hot extrusion of carbon steel solid sections. The use of the French Ugine-Sejournet process has made the extrusion of solid steel sections economically possible. Extruded shapes are produced by forcing steel billets through a die under hydraulic pressure. Extrusion temperatures range from 2100 to 2350 F. The lubricant used in this process is powdered glass which becomes molten at the extruding temperatures and furnishes lubrication between the die and billet.

This process as originally used in this country was directed towards the production of high alloy, thin wall tubing. Realizing the great flexibility of steel extrusions, the process was soon developed to produce solid extruded shapes. The greater percentage of hot extruded shapes are subsequently cold drawn to produce a shape of greater dimensional accuracy and better physical properties.

The main advantage to the steel user lies in the ability to purchase shapes which are close to their finished part shape and dimensions, thus saving costly machining and finishing. Hot extrusion followed by cold drawing can furnish shapes so intricate that rolling would be impossible or at best very costly. Extrusion is also very helpful in furnishing small quantities of rollable shapes where rolling would be uneconomical.

The most promising present and potential market is to be found with manufacturers of business machines, machine tools, small arms, automobiles, and farm equipment. At the present time much effort is being directed towards the task of having engineers and purchasing people become familiar with the possibilities offered by extrusions. Steel fabricators are already becoming more familiar with the possibilities offered by steel extrusions, and are using more of these sections in their products.

"BALANCED PRESSURE COKE OVEN GAS DISTRIBUTION"

by H. V. FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio

H. V. FLAGG

▲ THE coke oven gas distribution system at Armco, Middletown and the provisions made for establishment of uniformly balanced pressures throughout the plant are described in this paper. Two coke plants supply gas to this system, one located ten miles away at Hamilton and the other at Middletown East Works, less than two miles from the plant.

The Hamilton coke plant disposed of its surplus gas to the local utility for many years, and was equipped with compressors, a large gas-holder, and facilities for removal of sulphur. A 16-in. line was built to East Works in 1942 to provide an additional outlet for coke oven gas. The service to the utility was discontinued entirely in 1948 and all the output was utilized at East Works.

The plant gas load at East Works was subject to rapid and extensive fluctuation with the result that plant pressures varied widely even though delivery pressures at the compressors were held within reasonable limits.

Natural gas was available so that the solution of the problem seemed to be in taking up the load swing with that fuel, introduced into the consumption end of the system. A mixing station was planned, following the practice used in peak reducing installations employing LP gas, where a rich gas is diluted to a combination of heat value and density which will replace the base fuel without disturbing burner performance.

If coke gas has heating value of 550 Btu and specific gravity of 0.4, while natural gas has 1050 Btu and 0.61 gravity, the mixture of natural gas and air to replace coke oven gas will be 71 per cent natural gas and 29 per cent air. This can be calculated by working out a mixture where the heat value of the mixture divided by the square root of the gravity of the mixture will be equal to 550 divided by the square root of 0.4.

The mixing station is so organized that a pressure regulator opens a natural gas valve when the line pressure drops below setting. The natural gas thus admitted is measured across an orifice plate in a meter run. A gas-air ratio regulator senses the amount of natural gas and opens an air valve to pass sufficient air to maintain the proportion desired, as measured across an orifice in the air meter run. The mixture of natural gas

and air is admitted into the coke gas system at a point convenient with respect both to load distribution and to station operation.

Air is chosen as the diluting agent for several reasons —it is easily available, its composition is stable, and it does not add to the load of inerts in the system. The amount of air addition is so small that no hazard of combustible mixtures is involved. The air so used merely serves as part of the combustion air supply.

The mixing station has been in operation since 1948 and has been entirely satisfactory. Improvement in furnace performance and fuel economy has been substantial. The stability of the natural gas-air mixture is better than that of the coke gas, so that the influence of mixed gas is always on the beneficial side.

The most distinctive feature of the mixed gas system is that no attention is paid to either heat value of the component gases nor of the mixed gas. The simple relationship of gravity and heat value of natural gas-air mixture to coke oven gas serves as the basis for the system.

Construction of a new coke plant adjacent to the Middletown Plant in 1953 made some changes in coke gas utilization necessary. The system had been operated at 18-psi level since the Hamilton compressors worked easily against this back-pressure. The Middletown coke plant boosters were specified to pump against a maximum of 10 psi, so that revision of the plant system to permit operation at lower pressure was necessary.

The logical outlet for the surplus gas from the new coke plant was No. 1 open hearth which was so located that it could be supplied from the Hamilton gas at higher pressure and with lower sulphur content. Additional piping was installed so that furnaces could be fired with either coke gas or natural gas, at will. Firing practice has been worked out on the basis of 70 per cent fuel oil and 30 per cent gas, which makes it possible to dispose of all the surplus coke gas, without need for bleeding, and with negligible interference with open hearth operation.

The remainder of the coke gas system is carried at 7 psi. The new coke plant booster pumps against this back-pressure plus the drop through the header and the spill-over valve which amounts to a little over 1.0 psi. The holder capacity at the new coke plant is adequate for reversals and charging surges only, so that the booster control is organized to pump the surplus gas away exactly as produced without occasion for bleeding.

Any surplus of Hamilton gas over that disposed at No. 1 open hearth is bled into the low pressure system through a spill-over valve which is controlled to maintain 18-psi back-pressure on the Hamilton line and also to prevent the low pressure system from building up pressure against the booster.

To summarize, the Middletown coke plant pumps all its surplus gas, as produced, into a system at 7.6 psi. The Hamilton coke plant, which has a 4,000,000-cu ft gas holder, pumps through a 10-mile line against 18 psi, as directed by a dispatcher located at the mixing station. The dispatcher orders gas from Hamilton as needed for the load at Middletown, subject to the amount of gas in the holder and in consideration of mill schedules and mixer station capacity.

The mixing station supplies natural gas-air mixture to the system as needed momentarily to take up the variations of supply and demand due to, first, the constantly changing delivery from the Middletown coke plant and, second, the load swings resulting from the operation of hundreds of burners throughout the plant operating on automatic temperature control.

The balanced-pressure coke oven gas system disposes of all the surplus gas from two coke plants without any bleeding to atmosphere, and with pressures throughout the plant maintained within a range of 0.5 psi. The device which makes such control practicable is the use of natural gas-air mixture to take up load swings.

"LOCAL AND INTERPLANT GAS DISPATCHING IN STEEL PLANTS"

by H. J. ROHM, General Coordinator, Fuel and Power, United States Steel Corp., Pittsburgh, Pa.

H. J. ROHM

▲ DISTRIBUTION of by-product and purchased gaseous fuels, and the usage of liquid and solid fuels and purchased power present many varied problems in the plants of the U. S. Steel Corporation in the Chicago and Pittsburgh districts. Each plant presents its own particular problems in fuel availability and usage, due to plant design and location.

The interconnection of plants through gaseous fuel systems and/or electric power systems requires close dispatching to obtain maximum economies and continuity of operation. Dispatching organizations have changed over a period of years due to the increasing complexity of gaseous fuel and electrical systems.

Telemetering has become very important in obtaining maximum economies and considerable installations have been made over the past fifteen years, particularly those for interplant dispatching. These installations have proven very beneficial in "tightening" operations to obtain the maximum economies possible and are of particular benefit during times of emergency.

The author illustrates with slides the various dispatching organizations, telemetering installations, gaseous fuel and electrical power systems now in use, and the changes which have taken place over the last twenty-five years.

Present day "normal" operations will be described giving volumes of fuels produced and/or purchased, with their usage in conjunction with metallurgical requirements for melting, heating and electric power manufacture.

Maximum usage of by-product fuels is foremost in all dispatching, and purchased supplementary fuels are regulated accordingly. System design is very im-

portant, particularly in affording maximum flexibility to meet the varying fuel availabilities and operating schedules.

"EXPERIENCES IN PURGING PLANTS . AND MAINS"

by HUGH E. FERGUSON, Chief Testing Engineer, The Peoples Gas Light and Coke Co., Chicago, Ill.

H. E. FERGUSON

▲ AS an introduction, the basic principles of inert gas purging are outlined. The major portion of the discussion consists of descriptions of ten or twelve unusual purging operations—ranging from simple mains to entire plants. Most of the purgings were performed in steel mill properties, and are offered to illustrate methods of meeting peculiar problems or conditions. Included are:

1. Expediting the purging of an 11-mile branched interplant main.
2. Counteracting valve in-leakage when purging a mile of 60-in. oven gas main.
3. Some peculiarities of spherical storage holders.
4. Pressuring versus inerting of LPG storage tanks.
5. Difficulties in purging oxide purifying boxes.
6. Purging and cleaning scrubbing towers.
7. Purging of oven underfiring system for holder repair.
8. Starting up of coke oven gas handling equipment.
9. Purging of blast gas plant to permit major repair.
10. "Spot" purging, or local inerting to permit minor repairs or changes.

The concluding remarks are arguments for wider use of purging, and specifically inert gas purging, in plants handling large volumes of flammable gases such as steel mills, refineries, etc.

"THE USE OF THE MODERN ASSEL MILL IN THE PRODUCTION OF SEAMLESS STEEL TUBING"

by CHARLES E. SNEE, General Foreman, Assel Mill, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

C. E. SNEE

▲ THE Assel elongator was originally developed at The Timken Roller Bearing Company and has proven its practical value in the production of high quality, close dimension controlled seamless steel tubing through the last twenty years of production.

This mill displaces the conventional high or automatic mill and the reelers in the equipment line necessary to the production of seamless tubes.

The mill, as originally conceived and as still employed, is a cross-rolling mill of three conic work rolls with humped contours. In rolling, the work piece is supported internally by a mandrel bar.

In the first of these mills, the mandrel bar was free floating, being stripped out of the elongated tubes in a separate operation at the end of the rolling cycle. This free-floating practice is still employed today but has been supplemented and in some cases replaced by newer techniques whereby the mandrel bar is partially or completely removed from the tube during the rolling cycle.

This paper gives a history of the conception and development of the mill, basic data on roll pass design, mill setups and rolling characteristics, mandrel bar practices, and rolling techniques.

"MODERNIZATION OF THE HOT AND COLD CONTINUOUS STRIP MILLS, BETHLEHEM STEEL COMPANY — LACKAWANNA PLANT"

by F. S. ECKHARDT, Chief Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

F. S. ECKHARDT

▲ THIS paper outlines the changes and additions made in the 1935 model 79-in. wide hot and cold strip mills at Lackawanna to substantially increase their productive capacity.

In the hot mill, capacity has been quadrupled by correcting and adding to the slab storage and preparation facilities, mill reheating furnaces, and making a radical change in the method of hot rolling—permitting thicker slabs to be rolled.

The cold mill department's production has been raised over seven times its original design figure by additions and modernization of practically all of the processing units, including major building expansions.

Most of the modifications were made in the period from 1947 to 1952. Much of the work was done in successive steps with a minimum of interference to operations and without any long periods of mill shutdowns.

Current production figures of the various producing units are given. Tonnage gains for each of the major steps are outlined to show the benefits derived from each.

"ROLLING OF THIN STRIP, PART II"

by M. D. STONE, Manager Research and Development, United Engineering and Foundry Co., Pittsburgh, Pa.

▲ THIS paper is the final section of a study of the rolling of thin strip, which in its first part (1953 AISE

M. D. STONE

Proceedings) showed how it is possible to accurately predict rolling performance, using a step-by-step method. This second part carries the theory further, and presents a nomographic chart method of calculating such performance, eliminating the step-by-step method and reducing the time required for such calculations from hours to minutes.

The second part also investigates further the characteristics of the small work roll, back-up driven mill — showing among other things that the energy required to roll (in hphr per ton for a given reduction) is greatly reduced, when rolling hard alloys, by using smaller work rolls as compared to large work rolls. Another rolling phenomenon, heretofore neglected, that is discussed is the matter of energy loss at the contact line or area between work rolls and back-up rolls, which may amount to a considerable power loss in certain cases, as confirmed by tests.

The theory and tests cited in these papers apply equally as well to hot rolling, and to cold rolling of thick strip — as the considerations are basic — but the errors in using simple methods and power test data do not result in misleading conclusions in such cases, as they do when rolling thin strip — hence the justification for the methods described herein.

"INTEGRATED ELECTRO-MECHANICAL PRESS PULLER DRIVE SYSTEM IMPROVES EXTRUSION QUALITY"

by R. C. SUTTLE, Application Engineer, Metals Div., Reliance Electric and Engineering Co., Cleveland, Ohio

R. C. SUTTLE

▲ AT the new Dow Chemical plant in Madison, Illinois, magnesium extrusions are now successfully produced in a variety of shapes, without intermediate straightening, through the aid of press "puller drives" — the end result of a series of evolutionary steps. The integrated electro-mechanical drive system has brought about a marked improvement in extrusion quality while eliminating the need for intermediate straightening of the extrusions.

One of the primary limiting factors in metal extrusion has been the need for intermediate straightening of the extruded metal before final straightening. Intermediate straightening has been an absolute requirement because of localized chilling of the extrusion die which caused the metal to be extruded in irregular curled shapes as parts of the die changed temperature relative to the other parts. Heaters are often installed in the die, but do not completely compensate for localized chilling. Up to very recently, most extrusions were carried away from the die only by the extruding process itself or manually. After envisioning an automatic process without intermediate straightening, several versions of tuggers were tried, but the indeterminate characteristics of hydraulic presses made it difficult to accomplish the desired results by conventional control means.

Steps were taken at Dow to improve the operation by the application of fully regulated, automatic drives. Wide tension range requirements and variations in extrusion rate required the consideration of what are known as "puller" drives. This fully automatic puller drive which was developed, reduced manpower requirements with all of the following steps now accomplished automatically and controlled by a single push-button at the central operating point:

1. Pulling the extrusion.
2. Extrusion cutoff.
3. Extrusion pullaway.
4. Extrusion release.
5. Puller head automatic return.
6. Final positioning.

The puller drive system has been highly successful in accomplishing the original requisites, and most advantageous in terms of installation ease and maintenance facility. Accurate puller tension is provided through the use of an air-loaded tensionmeter, thereby divorcing the normal mechanical and electrical variations. Of great importance is the fast action of the electrical equipment which is afforded by electronic regulators to enable high speed response to meet the indeterminate characteristics of the hydraulic presses. The automated cycle is integrated with the press and subsequent handling equipment to give fully automatic operation. Ease of installation and maintenance are provided by the utilization of "packaged" adjustable-speed control units.

"CONTRIBUTIONS TO ARC FURNACE OPERATIONS"

by L. A. WYND, Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.

L. A. WYND

▲ THE design, construction and operation of arc furnaces have been helped by many ingenious ideas coming from many sources.

This paper is based on the electric arc furnace installation at the Chicago plant of Republic Steel Corp., and discusses a number of details which have helped operations in that plant.

Serious voltage dips are eliminated by transformer design with impedance between the three windings somewhat higher than normal, resulting in a 3.25 per cent negative value for the equivalent reactance of the high voltage windings, which corrects line drop within these limits.

To offset the lagging power factor of the furnace load, 44,700 hp in 0.8 leading power factor synchronous

motors were installed for the 6600-volt mill load in the plant.

Automatic optimum current control is used on taps 5, 4 and 3 of the furnace transformers. Taps 2 and 1 are manually controlled by the operator. The use of optimum settings called attention to transformer temperatures. Each arc furnace transformer was equipped with three "hottest-spot indicators."

The use of optimum control, increase of transformer sizes and conversion to top charging necessitated better transformer oil cooling. This was accomplished by improved circulation and forced flow through well-designed heat exchangers. Oil maintenance was carefully mapped out.

Other items mentioned include improved tap changer leads between transformer terminals and tap changer terminals, rubber sealed secondaries, pressure relief valves on main tanks and on tap changer compartments, silver plating of all heavy connections in the secondary circuits, installation of rotating regulators, etc.

It is estimated that the use of top charging, optimum current control, increased secondary voltage and the various other improvements has increased production by 70 per cent.

"INCREASING CAPACITY OF LADLE CRANES"

by EUGENE WHITAKER, Mechanical Engineer, Granite City Steel Co., Granite City, Ill.

EUGENE WHITAKER

▲ INCREASING the capacity of existing open hearth furnaces quite often presents the problem of what should be done with existing ladle crane equipment.

Should it be replaced with new equipment of larger capacity or can the existing equipment be revamped to satisfy the new requirements?

Such was the case several years ago when Granite City Steel Co., as part of an overall expansion program, proposed to enlarge four existing 210-ton capacity open hearth furnaces to 250-ton capacity.

The existing ladle handling facilities consisted of two 270-net ton ladle cranes. These cranes represented a large capital investment and could not be readily replaced. Since these cranes were in excellent mechanical condition, it was decided to investigate the possibility of increasing their rated capacity to handle the increased loads.

An exhaustive investigation was started to determine what kind of loads and stresses might be expected in each component of the crane and the building.

The calculations resulting from this investigation are too numerous to be presented in this paper and are not to be discussed except for specific points of interest. They did, however, show that it was entirely feasible to redesign the cranes for additional load.

A minimum of crane downtime for rebuilding was of particular importance, as the No. 2 Open Hearth Department would be operating four furnaces with only one crane available for handling heats. It was imperative that the job be accomplished quickly.

This paper therefore discusses the following points:

1. Reason for rebuilding cranes.
2. Conditions under which the main hoist must be capable of operating.
3. Results of the investigation.
4. Planning and execution of rebuilding project.
5. Load testing of the crane and the results obtained.

The results of this project have been quite favorable and have been satisfactory for Granite City Steel Co.'s own particular requirements.

"REPORT ON STANDARDIZATION OF ADDITIONAL AISE MILL MOTOR FRAMES"

by M. B. ANTRIM, Chairman Mill Motor Committee, and Assistant Manager, Maintenance and Construction, Lukens Steel Co., Coatesville, Pa.

M. B. ANTRIM

▲ THE increasing power requirements needed for steel mill equipment as a result of heavier load requirements and higher speeds have made it desirable to add new larger frame sizes to the present standardized AISE mill motor line. Standards for the existing motors, covered by AISE Standard No. 1, include motors up to 200 horsepower. As a result of this trend, the AISE mill motor committee decided to add three additional frame sizes with mill ratings of 275, 375, and 500 horsepower for the one-hour, totally-enclosed, 75C rise rating. This work has been going on in cooperation with the motor manufacturers.

Although the work is not entirely complete, the proposed designs have been substantially set up and standardized. This paper will give a brief description of the new standard line and will also report on the present status of the standardization work.

"WELDED STRUCTURES AS APPLIED TO CRANES AND MILL EQUIPMENT"

by I. W. EVANS, Chief Welding Engineer, Morgan Engineering Co., Alliance, Ohio

I. W. EVANS

▲ SINCE the close of and during the war, great strides were made in the advancement of welding. These advances were pinpointed toward eliminating the objectonable variables normally associated with manual welding. Higher strength electrodes requiring less manual skills to deposit them have been

developed. Submerged arc welding has been developed to the point where most alloy steels can now be welded by using the appropriate combinations of wires and fluxes. In addition, where possible, submerged arc welding is coupled with automatic positioning fixtures to completely eliminate the welding operator variable. Some parts of cranes being welded by our organization utilizing this combination are: stripper barrels, ram casings, bridge girders, trolley sections for ladle cranes, stripper links, hoisting drums, etc. Mill equipment parts being welded using the same combination are: table beams, major components of beam straighteners, side guards and gears.

Other factors, such as the inability in many cases to determine the soundness of various types of castings, have forced the trend toward conversion from castings to weldments, since it must be assumed that steel plate is fundamentally homogenous and has relatively uniform properties that can be relied upon.

It is anticipated that in the very near future riveted structures will become obsolete and will be replaced by welded structures, as shown by the trend toward the acceptance of welded girders in the types of service heretofore considered questionable, such as ladle cranes, soaking pit cranes, stripper cranes, slab yard cranes, etc.

In addition, more codes are now permitting welded field connections in all types of service.

The aforementioned factors, plus the favorable economies and assured scheduling, make for the growth of fabrication by welding.

"IDEAL MAINTENANCE MACHINE SHOP FACILITIES"

by W. J. PEARSON, Machine Tool Engineer, Bethlehem Steel Co., Bethlehem, Pa.

W. J. PEARSON

▲ THE opportunity to set forth one's views on what the ideal maintenance machine shop should be is offered occasionally to some, but the possibility of putting them into practice occurs to only a few persons interested in this phase of the steelmaking industry.

Most individuals are concerned with the improvement and expansion of existing facilities. A hypothetical situation is presented herein with the hope that it may serve as a guide in the rebuilding of outmoded or inadequate shops into more practical facilities.

Machine shops should be considered as such, eliminating from the discourse such facilities as forge shops, fabricating and welding shops, heat treating facilities, specialty repair or manufacturing shops, though it is recognized that such are also essential.

The facilities are based on the maintenance requirements of an integrated steel plant of 450,000 net tons per month capacity. Such a plant includes coke ovens, blast furnaces, open hearths, blooming, structural, bar, hot and cold strip mills, power facilities and some of the usual specialty mills or manufacturing operations requiring such operations as turning, boring, drilling, planing, milling, grinding, threading, layout, assembly and testing, as well as specialized operations of which gear cutting is perhaps the best known example.

The machine tool equipment is the primary consideration with selection based on providing 40,000 direct man-hours per month. The tools are enumerated and justified by typical operations. Floor space is allocated with adequate space for laydown and assembly, and building requirements are described.

No shop is more efficient than the manner in which it is operated and while it is not within the scope of this paper to discuss personnel, control or order systems, etc., it is felt that no machine shop should be operated without standards as regards cutting tools. an organized procedure to control the sequence of operations, the tooling to be used and the policing thereof to insure minimum cost and necessary quality.

Training of operators, be they assigned to small or large, simple or intricate jobs, can be the means of making any shop, ideal or not, a better place to realize the possibilities of a sizeable investment in a very essential part of the integrated steel plant.

"FANS FOR IRON AND STEEL MILLS"

by ROBERT JORGENSEN, Assistant Chief Engineer, Buffalo Forge Co., Buffalo, N. Y.

ROBERT JORGENSEN

▲ TURBOMACHINES of all kinds including fans, blowers and compressors, are used in iron and steel mills, to pump various gases. Fans comprise that group of machines usually used for pressure rises of less than 1 psi or 27.7 in. of water and are generally constructed of steel plate. This, of course, distinguishes fans from both blowers and compressors which are generally constructed from cast shapes and designed for much higher pressure rises (up to 40 psi rise for blowers and even higher for compressors.)

Fans can be subdivided into various types. For instance, the two major categories, centrifugal and axial flow, can each be further subdivided. Common names for centrifugal types include industrial exhausters, ventilating fans, mechanical draft fans and others. This paper reviews the characteristics and applications of the various types of fans used in mills.

The applications which are discussed include sintering duty, mill motor ventilation, fume exhausting, mechanical draft and others.

Although considerable emphasis is given to recent developments in the fan industry, fundamentals such as "fan laws," fan-system characteristics, control methods, etc., are discussed in detail. Reference is made to performance curves to illustrate some of these fundamental situations.

"PROTECTIVE COAL TAR COATINGS IN STEEL PLANTS"

by DR. W. F. FAIR, JR., Coatings Consultant, Tar Products Div., Technical Dept., and H. J. CIBULA, Sales Representative, Tar Products Div., Sales Dept., Koppers Co., Inc., Pittsburgh, Pa.

DR. W. F. FAIR, JR.

H. J. CIBULA

▲ THIS paper presents general information on the importance of corrosion mitigation, proper design, surface preparation, requirements and desirable properties for long-lasting heavy duty coatings, and the important fundamental properties of coal tar coatings which have been used to protect metals from different corrosive environments for nearly a century.

Individual types of hot applied thermoplastic and cold applied coal tar coatings are then described. Application and results obtained with such coatings in four separate steel plants are given in detail, and general recommendations offered for steel plant maintenance and corrosion prevention by use of these coatings.

"STEAM-FUEL RATIO CONTROL AS APPLIED TO OPEN HEARTH FURNACE OPERATION"

by W. H. KAHL, Combustion Engineer, Open Hearths, Inland Steel Co., East Chicago, Ind.

W. H. KAHL

▲ STEAM, due to appreciable economic advantage, remains the basic atomizing agent for liquid fuel through the steel industry of the country.

A brief review is presented of the generally accepted method of controlling and operating the steam section of the open hearth furnace manifold. Included are some of the advantages and disadvantages inherent in a strict manually operated steam manifold. Associated in this discussion are such factors as pipe size, insulation, valving, pressures, volumes, atomizer types and location and the burner employed.

From the foregoing, the author develops the background for the installation of steam/fuel ratio control equipment in the new No. 3 shop of the Inland Steel Co. A summary of the developments in this shop employing accurately measured amounts of steam versus liquid fuel throughout the various stages of the heat, and the complications encountered and solved is then presented.

Encouraged by overall results in the No. 3 shop, a description of the installation of this type equipment in connection with a completely automatic electronic Btu summarization system on four completely rebuilt and modernized furnaces in the No. 2 shop at Inland Steel follows.

Again, a discussion of operating problems and the results to the present time are presented.

Finally, the author reviews some of the basic fundamentals that must be observed for any type of efficient steam atomization and presents some of the advantages found in the initial installations of steam/fuel ratio control equipment in two of the open hearth departments of the Indiana Harbor Works of the Inland Steel Co.

"DEVELOPMENTS IN STEAM GENERATION FOR STEEL PLANTS"

by F. X. GILG, Executive Assistant, and NORMAN W. YOUNG, Assistant Chief Staff Engineer, Boiler Div., The Babcock and Wilcox Co., New York, N. Y.

F. X. GILG

▲ THE process of making steel creates by-product fuels. The increasing dollar premium placed on prime fuels makes efficient utilization of by-product fuels mandatory in most steel plants. The use of blast-furnace gas and coke breeze has been a major factor affecting the development of steam generating equipment for steel mills.

Coke breeze has a very low volatile content and is a difficult fuel to burn efficiently. The combination of special furnace design, reflecting arches, and the use of a traveling grate or chain grate type stoker has thus far provided the most practical method of burning this fuel. The author reviews the many difficulties involved in burning coke breeze, the knowledge gained, and the advances made.

N. W. YOUNG

Since the demand for steam in most steel plants is fairly constant and the supply of by-product fuels is usually variable, steam generating units should be designed to fire each fuel individually or in any combination with coal and oil. Thus, it is not uncommon to have a unit designed to fire coal, oil, blast-furnace gas, and coke-oven gas. The use of combination fuels creates many design and operation problems from the standpoint of cleanliness, steam temperature, efficiency, draft loss and combustion control. These problems have existed from the time of the earliest installations. Advances in any field are usually

the result of overcoming past difficulties. The development of the steel plant boiler as we know it today is the result of accumulated knowledge gained from field experiences. The author discusses some of the difficulties experienced, their eventual solution and the resulting new developments in efficient steam generating units for modern steel plants.

"NORMALIZING AND QUENCH-AND-TEMPER HEAT TREATMENT OF STEEL PRODUCTS"

by JAMES MacGREGOR, Board Chairman, York-Gillespie Manufacturing Co., Pittsburgh, Pa.

JAMES MacGREGOR

▲ THIS paper deals in the quench and temper heat treating methods to produce high tensile property steel for tubular products to meet the ever-expanding A.P.I. standards. The quality requirements for many grades of steel can be brought up to higher standards by various methods of heat treatment, where it is possible to alter the granular structure of lesser grade products to the equivalent of a higher alloy product. The method of large tonnage production heat treatment, as outlined in this paper, permits an average of between 30 and 45 tons per hour on a continuous basis. The author's company developed, designed and built the mechanical equipment for the two furnaces at Jones & Laughlin Steel Corp.'s Aliquippa Works.

In view of the present interest in this installation, it can definitely be seen that it will be the forerunner of larger tonnage capacity installations and, at the same time, will afford the opportunity of developing similar equipment to rotate other steel products that can be heat treated in a similar manner to effect high tensile properties. Similar type furnaces would also be suitable for normalizing and similarly heat treating hot extruded steel products to much the same extent that is being performed with tubular products to meet the A.P.I. standards. The equipment itself has been designed to handle a wide variety of tubular products from 2⅜ in. to 10¾ in. in diameter on the same equipment without any mechanical modifications other than the speed of the mechanical equipment, to increase or decrease the rate of transfer through the furnace.

The paper is accompanied with slides to show the basic design and operation of the Jones & Laughlin installation.

"INCREASED STEEL PRODUCTION FROM DESILICONIZED HOT METAL"

by E. C. WRIGHT, Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.

E. C. WRIGHT

▲ THIS paper contains a survey of the existing open hearth and electric furnace facilities for making steel in the United States and then presents a theoretical study of the affect of using desiliconized hot metal (wash metal) on the production rates of the furnaces when various amounts of wash metal are included in the charge instead of normal hot metal containing 4 per cent carbon, 1 per cent manganese, and 1 per cent silicon at the usual mixer temperature of 2450 F. When normal hot metal is blown with oxygen to about 3 per cent carbon, 0.40 per cent manganese and 0.20 per cent silicon the temperature rises to 2950 F. The use of this superheated wash metal has a marked effect in increasing open hearth furnace output. The adoption of this practice in substitution for normal hot metal charges would increase production capacity at least 65 per cent for present open hearth installations.

The use of normal hot metal (4 per cent carbon) in large amounts in electric furnaces does not seem feasible because of the large slag volume and gas evolution which results. This paper makes a study of the effect of charging a desiliconized wash metal containing 2 per cent carbon, 0.20 per cent manganese, and 0.10 per cent silicon and shows how such a charge will greatly increase output over present cold scrap melting practice. Such a charge, consisting of 60 per cent desiliconized wash metal and 40 per cent scrap apparently doubles electric furnace output and decreases power and electrode costs 40 to 50 per cent. The calculations present a theoretical view of the possibilities of the desiliconizing operation upon the melting practices in both open hearth and electric furnaces, located at integrated steel plants where ample supplies of hot metal are available. The main objective of the author is to enable operating steel men to get a broad picture of how oxygen blowing of normal hot metal is a cheap and rapid method for making steel.

"OXYGEN STEEL IN UNITED STATES"

by C. R. AUSTIN, Manager, Oxygen Steel Div., Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

C. R. AUSTIN

▲ A short resume of the history of oxygen steel produced by top-blowing is given. Production of oxygen steel here and abroad is summarized. Production cycles employed in United States and in other countries are discussed. A general description of the oxygen steel plant at McLouth Steel Corp. is presented and general operating practice is discussed from the standpoint of duplexing in the electric furnace, which was empoyed originally, and also direct top-pouring of ingots which is now followed. Type of steel made and residual elements remaining after blowing are considered.

"RECENT DEVELOPMENTS IN SINTERING AND PELLETIZING"

by EDWIN N. HOWER, Manager, and JOHN A. ANTHES, Process Engineer, Industrial Dept., Dravo Corp., Pittsburgh, Pa.

E. N. HOWER

▲ THIS paper discusses recent improvements in sintering and pelletizing techniques with particular emphasis on certain developments which originated in Europe and which are now being adopted in the United States. The paper is divided into two main parts, sintering improvements and pelletizing improvements. The sintering improvements are classified into four classes:

Improvements due to increased rates per units area as a result of getting more air through the bed. A second improvement has been in the use of larger sinter machines, reducing the number of units necessary for large scale production of sinter. Improvements have also been made in durability of both the sinter machines and auxiliary equipment. A fourth class of improvements is those which have improved the quality of the sinter produced.

J. A. ANTHES

The portion of the paper on pelletizing contains a brief discussion of the factors which dictate the use of pelletizing rather than sintering. The discussion of pelletizing is divided into two main classifications, improvements in pellet formation and improvements in pellet sintering.

The paper is illustrated with photographs and drawings.

"THE INSTALLATION OF, AND SPLIT WIND BLOWING WITH, TOPPING TURBO-BLOWERS FOR BLAST FURNACES"

by E. O. AUSTERMILLER, Chief Engineer, and W. A. SMITH, Superintendent, Power and Fuel Dept., National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

▲ SPLIT wind blowing with topping turboblowers at National Works is unique for two reasons. First, with the use of topping turboblowers, it is possible to provide blower operation for blast furnaces with only about one-third the Btu required by a modern condensing steam turboblower operation, and second, it provides a method of utilizing the full capacity of blowers with the added safety of two blower operation on a furnace.

E. O. AUSTERMILLER

W. A. SMITH

The installation at National Works of a new boiler house with five boilers rated at 175,000 lb per hr, 850-psi 750 F total temperature steam provided the means to make this installation possible. Using this 850-psi 750 F steam through a topping turboblower leaves more than ninety per cent of the Btu in the steam after the work of driving the blowers has been accomplished.

The two topping turboblowers installed at National Works are each rated at 10,400-hp and at full load use 200,000 lb per hr of steam. This exhaust steam at 150-psi 450 F total temperature is then used for normal plant usage such as blooming mill drives, bessemer turboblower drives, turbine generation, etc.

Split wind blowing is accomplished by designing a flexible header system for the two blowers by which it is possible to blow any of the four blast furnaces from either blower. Each furnace uses approximately 60,000 cfm of air for full blast. Each of the two blowers is rated at 90,000 cfm at 30 psi. Thus any three furnaces can be blown from the two topping turboblowers. The desired furnace combinations can be selected by motor operated valves.

The cold blast main to each furnace is provided with an automatically controlled butterfly valve for maintaining desired flow to the furnace, an orifice plate for metering and controlling the wind to that furnace, suitable pressure and temperature indicating and recording instruments and an automatic control system that will maintain the desired pressure on the common header.

With such a system designed and installed as at National Works, split wind blowing has a pressure one to two psi higher in the discharge header from the turboblower than the highest furnace pressure on the system. Flow to each furnace is then controlled automatically by the butterfly valves.

Communication is especially important in an operation such as this, so in order to communicate with the blast furnaces, two separate systems of communication are installed. The first and the one that is used to operate the furnaces and the turboblowers is a system which provides:

1. A siren which calls either to each furnace cast house or from each furnace cast house to the turbine floor with an indicating light showing the number of the furnace.
2. An answering button which advises the party that the signal has been received.
3. A selsyn motor operated signaling system which

will indicate full wind, stand-by, check and slow blast.

In addition to the selsyn communicating system, there is provided a two-way P. A. system between the turbine operating floor and each blast furnace and also to the boiler house. This P. A. system is used for conversation only and would be used in case of failure to the selsyn communication system. The selsyn system is used entirely for operating the furnaces and the turboblowers.

"UNDERHEARTH COOLING OF THE BOTTOM OF BLAST FURNACES: TEMPERATURE DISTRIBUTION AND HEAT EXTRACTION"

by VICTOR PASCHKIS, Technical Director, and TAGHI MIRSEPASSI, Research Assistant, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

PROF. V. PASCHKIS

▲ CONTINUING the theoretical study of the design of the bottom of blast furnaces (see Iron and Steel Engineer, February, 1954), the influence of the extent of carbon in radial and axial direction on the depth of penetration of iron was explored. The investigations were carried out for the two cases of having or not having underhearth cooling.

A number of diagrams are presented, each showing the depth of penetration for a different lining design.

Several conclusions of practical importance can be derived from the graphs. Best thermal use of carbon is made if it is placed on the outside rather than, as sometimes customary, on the inside since for a given volume of carbon, the freezing lines are farther away from the outer surface if the carbon is on the outside, instead of the inside.

TAGHI MIRSEPASSI

Underhearth cooling results in relatively small change of depth of penetration near the sides, where a breakout may occur; but it results in large changes at the center. Thus, underhearth cooling results in smaller salamanders, but does not give a considerable increase of safety against lateral breakthrough.

A separate investigation covered cooling requirements of underhearth cooling and of cooling staves. For the latter, considering an effective thickness of five inches, the conductivity is of great importance.

"FACTORS IN SOLVENT SELECTION AND CONTROL OF HAZARDS IN THE STEEL INDUSTRY"

by JOHN B. MOORE, Technical Director, John B. Moore Corp., Nutley, N. J.

JOHN B. MOORE

▲ IN this paper, the author reviews practices which are prevalent in many parts of the iron and steel industry, which relate to solvents used in various maintenance and production operations. The premise is advanced that the rapid rise in standards of tolerance of present-day equipment, as well as higher standards of quality of finished products, have raised solvent selection standards to engineering levels.

At the same time it is noted that toxic and fire aspects of solvents must be given equal consideration with product efficiency in intended use. Tabular data covering a representative list of commonly used solvents is combined to show solvency, volatility, flash-points and toxic exposure tolerance levels. The conclusion is made that solvent selection and the manner of use is properly a function of team decision, the team being composed of engineers, operating supervisors responsible for the use and application of solvents, safety engineers, fire marshal and industrial hygienist.

In many cases, where the change has not already taken place, there is need for reorientation of viewpoint to coordinate staff objectives with those of operational levels. All solvents are potentially hazardous. Improper selection, as well as inadequate control of both the manner and area of use, can jeopardize both profits and capital structures.

The author suggests four practical steps to improve solvent-cleaning efficiency and to reduce accident losses incident to the use of solvents. These are: (1) selection of solvents on the basis of what they must do and their application environment, (2) coordination of fire, safety and hygiene functions with operating requirements to assure proper application of hazard control measures, (3) setting standards of quality control, and (4) education of personnel and product labeling programs adequate to gain cooperation at all plant and staff levels.

The conclusion is advanced that solvent hazards are controllable and that, through application of engineering principles to the selection and use of solvents, efficiency will be improved, costs lowered and accidents largely eliminated.

"ADDITIVES IN STEEL MILL LUBRICANTS"

by M. S. CLARK, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

▲ THE use of additives in steel mill lubricants has increased greatly in recent years. There are several rea-

M. S. CLARK

sons: (1) steel mill service is usually very rugged and fortified lubricants are often necessary; and (2) in recent years there has been a tendency to speed up machines well above their original rated capacity, to a point where additives are necessary to provide proper lubrication under all sorts of adverse conditions.

The following shows types of additives that are often used in various steel mill lubricants:

Lubricants	Types of additives
Greases	Lead, sulphur, chlorine or phosphorus type extreme pressure compounds. Polar compounds. Oxidation inhibitors. Solids such as clay, silica, graphite, molybdenum disulphide, zinc oxide.
Gear oils	Lead, sulphur, chlorine or phosphorus types of extreme pressure additives. Anti-foam compounds. Polar materials. Solvents.
Heavy duty motor oils and diesel lubricating oils	Pour depressants. Viscosity index improvers. Detergents. Anti-foam compounds.
Turbine oils	Oxidation inhibitors. Rust inhibitors. Anti-foam compounds.
Steam cylinder oils	Fatty oils.
Rustproofing or slushing oils	Polar materials or emulsifiers.
Rustproofing compounds (heavy)	Polar materials, emulsifiers and certain protective salts.
Pipe thread lubricants	Powdered zinc, lead, copper and graphite.
Roll oils	Palm oil, tallow and other polar materials. Soluble oils and other emulsifiers.
Soluble oils	Soaps, sulphonates and other emulsifiers. Rust inhibitors Bactericides.
Cutting oils	Sulphur, phosphorus and chlorine Ep compounds. Polar materials.
Quenching oils	Polar materials and other wetting agents.

Each of these additives has a specific purpose and all have proven to be effective in laboratory tests and in plant operation.

The additives are not always simple chemical compounds; many commercial additives are mixtures, and the exact chemical structure of the active ingredients is uncertain. Comparatively small concentrations of additive in the range of 0.01 to 5.0 per cent are usually sufficient to provide the desired effect.

It is estimated that approximately half the lubricants used in steel mills now contain additives. The day may not be too far distant when practically all lubricants will contain additives of one kind or another.

"SELECTION OF A LUBRICANT FOR COLD DRAWING" PART I "COARSE STEEL WIRE"

by BRUCE W. SIEMON, Standard Industrial Compounds Co., Chicago, Ill.

B. W. SIEMON

▲ STEEL wire represents the most highly finished product of the Steelmakers art. The term coarse wire, usually implies wire 20 gage (0.035 in.) and heavier, and is generally drawn with a dry lubricant.

Because of the complex nature of the lubricants function in drawing wire, it bears examination before attempting to select a satisfactory lubricant. The bearing portion of a wire drawing die is vastly different from the ordinary bearing, where unit pressures are in the magnitude of a few to a relatively few thousand psi. In the wire die are found pressures ranging from 100 to 400,000 psi.

The lubricant plays only a minor role in overcoming frictional forces, its principal function being that of forming a plastic tube or coating around the wire, which in turn prevents contact between the die and the wire. Failure of the lubricant occurs when this plastic tube becomes so thin through its stretching with the elongated wire, that contact between the wire and the die is permitted; or through a decomposition of the tube due to excessive heat.

Factors to be considered in selecting a wire drawing lubricant are:

1. Speed of drawing.
2. Severity of drawing.
3. Material being drawn.
4. Finish desired or end use of product.

Greatest emphasis being placed on the last item, for it is possible to find lubricants that meet the conditions imposed by the first three factors, and yet are totally unsatisfactory by virtue of producing a finish on the wire that is unsuited for the end or subsequent use of the wire.

Oils, greases, and soaps are the most commonly used lubricants employed in drawing coarse steel wire. The oils by virtue of their inability to form sufficiently thick coatings are generally confined to single drafts of relatively slow speeds. They are generally employed where a bright finish is wanted. The greases are capable of being drawn further than the oils and will withstand somewhat higher speeds. The greases again find application where bright finishes, clean surfaces, or ease of removal are the prime requisites. The soaps are the most widely employed in drawing multiple drafts at high speeds, and find greatest application where some form of coating remaining on the wire is desired.

By an understanding of the lubricants available and the factors influencing choice of lubricants it is possible to select the lubricant most suited for the particular set of conditions imposed.

PART II "FINE STEEL WIRE"

by W. B. BAUZENBERGER, Sales Manager, Apex Alkali Products Co., Philadelphia, Pa.

W. B. BAUZENBERGER

▲ BEFORE attempting to select the proper lubricant for drawing fine steel wire, it should be understood what function the lubricant must perform in the drawing operation.

The principal function of a wire drawing lubricant is to reduce friction, and prevent metal to metal contact between the die and the wire being drawn thus eliminating scratching and eventual breaking of the wire.

In the drawing of fine wire where relatively high speeds are encountered, it is most essential that the lubricant cool the wire as well as lubricate the drive cones or rolls of the drawing machine itself.

Lubricants alone are not wholly responsible for successful drawing practices, as it is imperative that the metal be prepared or made susceptible to lubrication. By so doing, a coating in the form of lime, zinc iron phosphates, copper or other metallic platings must be deposited on the surface of the wire to act as a lubricant carrier. The coating on the wire will pick-up and carry the lubricant through the die and reduce the possibilities of metal to metal contact referred to previously.

Fine wire drawing lubricants are divided into four classes and are used in accordance with the demands of the wire being drawn.

1. Straight soap lubricant.
2. Emulsion type or soap fat lubricants.
3. Petroleum oil or petroleum oil derivatives.
4. Water soluble oils.

Each of the foregoing types of lubricant are consumed by the manufacturers of fine steel wire today, the choice of which depends on the metal being drawn and the finish requirements.

Caution must be exercised in the choice of a water miscible lubricant as its stability is easily effected by water hardness or contamination due to the carry through of acidic type coatings.

For the most part, sintered carbide dies are recommended for the drawing of fine high and low carbon steel wire, and diamond dies for stainless and alloy wires.

We have all noted the great influx of steel alloys in the wire industry in the past ten years resulting in many improvements and new developments of fine wire lubricants for the consumer today.

"HEATING HEAVY SECTIONS — HOW FAST?"

by QUENTIN BLOOM, Project Engineer, Selas Corporation of America, Philadelphia, Pa.

QUENTIN BLOOM

▲ DEVELOPED originally for small parts and thin sections, fast heating has been adapted to include medium and heavy sections, of sizes which are of interest to the steel industry.

Several steel mill installations, employing high-speed gas heating methods, at heating rates until now not considered possible and practical, are described.

In one instance, alloy steel die blocks on the order of 66 x 24 x 18 in. and larger, are heated to 1550 F, for hardening, in only about 15 per cent of the time cycle previously considered necessary. Automatic control of complete heating cycle assures reproducible uniformity of workpieces. Current production on the order of 3,500,000 lb of die blocks per month, certifies that fast heating with gas is practical and safe. Performance data and curves will be shown.

Operating data is also presented on two steel mill installations, one involving the heating of 23-in. diam x 78-in. long ingots for piercing, and the other, introducing some novel design features, is employed in heat processing ingots 19 x 23 x 78 in.

The short-time cycles result in increased production rates, as well as savings through reduced scale losses, as the outstanding benefits of fast heating. Other potential advantages pertaining to ingot heating, from the standpoint of steel mill layout and capital investment, are explored.

Comparison is also made with recent published data concerning European practice in the heating of large steel sections for which heating rates have been established.

"ELECTROSTATIC APPLICATION OF MATERIALS IN THE STEEL INDUSTRY"

by DR. EMERY P. MILLER, Director of Research and Development, Ransburg Electro-Coating Corp., Indianapolis, Ind.

DR. E. P. MILLER

▲ THE electrical principles underlying the operation of electrostatic coating processes as well as the physical arrangements of the equipment used in the various commercial processes are reviewed.

The manner in which these processes are applied for general finishing of manufactured articles is discussed and the merits of these processes over other methods are pointed out. The limitations of electrostatic methods with regard to materials, space requirements, production speeds, etc., are considered. Those specific applications which have been made in the basic steel industry and the results obtained with these units are considered in detail. A film showing the methods and their operation on various applications will be shown following the general discussion.

"ELECTRIC OPEN HEARTH COMBUSTION CONTROL AT ALGOMA"

by A. K. BAYLES, Chemical Engineer, and D. H. STANTON, Fuel Engineer, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

A. K. BAYLES

D. H. STANTON

▲ THE paper describes the electric combustion controls installed on the two 330-ton open hearth furnaces at Algoma. The features of instrumentation and controls that were required are outlined, with some of the factors considered in the selection of the equipment.

The fuel-air ratio, steam-oil ratio, fuel input totalizer, checker temperature, roof temperature control, automatic reversal and other features are explained. The operation of the control board is outlined showing the sequence of events that takes place when the first helper changes control settings.

The performance of the control system from the operating and maintenance side is discussed since it was put into operation.

"THE PRACTICAL APPROACH TO COIL SPLICING"

by R. E. MORTON, Vice President and General Manager, Morton Manufacturing Co., Muskegon Heights, Mich.

R. E. MORTON

▲ THE ceaseless demands of the steel and non-ferrous industries for coil joining method suitable for handling a wide range of material types in gages from 0.009 to 0.250 in. thick, have spurred machinery manufacturers to develop new equipment and processes to meet that demand. The further requirement that such equipment be suitable for operation by unskilled labor has led to a high degree of automation and a resulting application of hydraulic, electrical and mechanical components which must be kept operative by mill maintenance engineers. The application of submerged arc, tungsten inert gas, and metallic inert gas welding to hot and cold rolled mild steels, stainless steels, and silicon steels as well as non-ferrous materials such as copper, bronze, aluminum and magnesium, has presented several serious problems requiring extensive research and developments.

One practical solution to such a problem is a design which incorporates the following components:

1. Automatic entry and exit strip centering.
2. High pressure primary strip clamping adjacent to the joint.
3. Double blade up-cut shear die set with strip hold down.
4. Positive primary clamp jaw push up to close the gap.
5. Positive movement of the strip and clamps to accurate weld location.
6. High pressure secondary clamping on strip by welding unit.
7. Automatic multiple electrode weld followed by trimming tools to remove surplus metal deposited (heavy gage welds).

7a (Alternate) Interchangeable close clamping and rigid back up bar to handle light gage material where trimming is not required.

8. Remote preselection of welding conditions for varying materials.
9. Quick interchange of die sets, clamps, back up bars and all components subject to maintenance or replacement while line is in operation.

Other automatic features which make it possible to operate with unskilled labor are:

1. Remote preselection of all weld conditions for varying materials with panels preset and locked.
2. Quick change die sets with proper knife clearance for varying thicknesses.
3. Quick change auto stops for joint spacing control.

One of the greatest challenges from a design standpoint lies in producing a machine with the aforementioned features, which can still be maintained with strip material traversing through the machine. The changeover time to replace such units as shear die sets, back up bars, clamps, or welding torches should not exceed the length of time it takes to run one coil at line speed into a storage facility such as a looping pit or accumulator. This should be accomplished without line shut down.

The high degree of automation incorporated in coil splicing machinery necessarily requires closer tolerances in manufactured parts, and a higher degree of inspection to make parts completely interchangeable without hand fitting. This also places greater demands on steel mill engineering and maintenance groups to still further improve technical skill and knowledge of hydraulic, electrical and mechanical equipment.

Steel mill and machine manufacturing men, have just scratched the surface of coil splicing development. Combined efforts are needed to improve welding methods and mechanical handling techniques. The ultimate goal is to produce good welds in a wide range of materials with a minimum cycle time.

"DEVELOPMENTS IN SCALEBREAKING AND CONTINUOUS PICKLING LINES"

by J. I. GREENBERGER, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

▲ PAPER develops importance of a proper mechanical scalebreaking process prior to acid pickling. Various mechanical scalebreaking methods such as

J. I. GREENBERGER

cold rolling, stretching and flexing are mentioned.

A series of fundamental tests are discussed and the relationship between surface strain and resultant effectiveness of scalebreaking is established. The basic similarity of response of various types of hot mill oxides to the mechanical scalebreaking process is shown.

Design features of these scalebreakers are discussed, emphasizing flexibility and ruggedness. Several years of operating experience have more than confirmed original test predictions and a recent full scale field test showed excellent pickling of continuous hot mill type of oxide with less than 25 seconds of acid immersion after passage through the scalebreaker. Flexing rolls operate a month and backing rolls four to five months between grinds.

Having excellent scalebreaking means available, the fundamental relationships existing in the overall continuous pickling line are developed. The correlation between coil length, downtime, entry zone speed and pickle zone speed is analyzed and results developed which indicate the desirability of modifying entry ends of continuous pickling lines to a double entry looping pit arrangement.

Potentialities of combining good scalebreaking with double entry looping pits and shorter acid tanks are developed to show that reasonable entry speeds, high production and various economies are possible. Photographs of operating scalebreakers and shop views of a new 70-in. machine as well as a nomograph for establishing pickle line productions are presented.

In general, the paper offers solutions to the two related problems of scalebreaking and increased mechanical pickle zone speeds.

"RECTIFIER EQUIPMENT TO SUPPLY D-C POWER IN STEEL MILLS"

by C. S. HAGUE, Manager, Power Conversion Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

C. S. HAGUE

▲ THE steel industry requires large amounts of d-c power for three principal applications:

1. 250 volt constant potential supply for auxiliaries.
2. 700 volt variable voltage supply for main drive motors.
3. 6 to 48 volt supply for tinning and cleaning lines.

Although the conversion equipment for all of these applications initially consisted of rotating machines, static rectifiers are now being extensively used for all applications.

The high efficiency, low installation cost, and low maintenance of the mercury arc rectifier have enabled it to dominate the 250-volt application and its use as a main drive power supply is steadily increasing despite certain inherent limitations.

A newcomer to the field, the germanium semi-conductor rectifier is now commercially available and fulfills to a large degree the ideal requirements of a highly efficient, reliable, low maintenance conversion device for applications at d-c voltages below 50.

"MODERNIZATION OF AN INDUSTRIAL PLANT POWER DISTRIBUTION SYSTEM"

by A. C. STOEVER, Superintendent of Utilities, Granite City Steel Co., Granite City, Ill.

A. C. STOEVER

▲ THIS paper traces briefly the earliest operations of the Granite City Steel Co., particularly with reference to power, beginning in the middle 90's. Steam power was employed to drive the rolling mills, and the relatively small amount of electric power used was produced with engine-driven d-c generators. The earliest belt-driven machines were replaced by direct-connected engine-driven generators and eventually by steam turbine-generators.

The replacement of steam-driven sheet and tin mills by motor-driven mills is related, culminating with the installation of modern strip mills in the middle 30's. This required considerable increase in electric power requirements which was met by expansion of the company's power plant.

As the capacity of the plant increased, there were several periods of rather extended length when purchased power was utilized to supply particular departments as isolated units.

The latest major expansion program of the company (1951 to 1953), whereby it attained a million plus tons of ingots per year status, required still more power and resulted in the present parallel operation of the company's power plant with the public utility. The equipment selected and the operating practices of this arrangement are outlined in some detail.

There are numerous situations and conditions peculiar to the power operations of this company wherein economies may be effected. The manner in which these matters are handled is described at considerable length.

The problems and conditions which arise in such a power operation are as numerous and at times as trying as those experienced by some of the larger steel companies with similar operations, many times as large. Granite City Steel Co.'s manner of handling them is perhaps somewhat different and quite fully related in the paper.

"DISTRIBUTION OF POWER IN A MODERN COLD MILL"

by E. A. YOUNG, Superintendent of Maintenance, Sheet and Tin Mills, Indiana Harbor Works, Youngstown Sheet and Tube Co., East Chicago, Ind., FRANK NOLAN, Switchgear Engineer, and A. D. MILLIKIN, Rectifier Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wisc.

E. A. YOUNG

FRANK NOLAN

A. D. MILLIKIN

▲ THE installation of the new cold mill at Youngstown Sheet and Tube Co., Indiana Harbor Works, required an additional 20,000 kw for full production. Inasmuch as this power was not available within the plant, the new mill obtains the necessary power from a public utility. The main incoming substation is located as near the center of the load area as possible and also has a location where it will not interfere with future expansion. The power is brought in at 34.5 kv through an underground line. Distribution from this substation is through an 11,000-volt system run underground in nonmetallic ducts or on cable racks through the basement. The use of the underground system has been advantageous since it has cut down outages due to storms or other disturbances. All ducts are fireproofed wherever exposed. An emergency tie with the hot strip mill is provided which can handle 30,000 kva. Transformers at the main substation also provide 2300-volt power through two 5,000-kva transformers. Power at 440 volts is also provided through 2300/440 volt unit substations. Two 1,000-kw mercury arc rectifiers furnish the 250-volt d-c power.

"LUBRICATION — SYSTEMS AND APPLICATIONS AT FAIRLESS WORKS"

by W. E. RIGOT, Lubrication Engineer, United States Steel Corp., Fairless Hills, Pa.

▲ THIS paper is a combined critique and progress report on some of the originally installed lubrication systems which are in use at the Fairless plant. Such systems were extensively used. The 80-in. hot strip mill, for example, has five main circulating oil systems, and twenty centralized grease systems which serve about 4000 bearing points. The oil system which serves the backup roll neck bearings is discussed in detail. It is

W. E. RIGOT

typical of most of those in use at the Fairless Works. With proper maintenance, they have performed especially well on the mill. Other similar systems are giving good service on the turbo-generators, turbo-blowers, main mill motors, motor-generators, mill pinion stands, speed reducers, screw down drives and all oil-film roll neck bearings.

One feature which has helped in the trouble-free operation is that regardless of what type of pipe was used, the systems were flushed prior to initial start-up. The grease systems also have given good service. One unique innovation is the method used to fill the supply reservoir. Another feature to which a great deal of attention was given in the design was the erection of signal devices to indicate operation of the systems.

"OIL MIST LUBRICATION AND SOME OF ITS APPLICATIONS IN THE STEEL INDUSTRY"

by T. M. MURPHY, Manager Industrial Sales, Alemite Div., Stewart-Warner Corp., Chicago, Ill.

T. M. MURPHY

▲ THE past five years have seen many successful applications of the oil mist method of lubrication. However, numerous inquiries and reports from the field, on its ever-widening application, indicate that a review of the oil mist principle of lubrication is in order.

Oil mist lubrication may be defined as a method of converting liquid oil into an airborne mist state that may be conveyed in an air stream through a system of piping to a number of bearings for the purposes of lubrication.

The objectives of lubrication being sought after, that led to the development of the oil mist principle, were the desire to have continuous controlled lubrication for high rotational speed anti-friction type bearings and to provide an effective protection for these bearings against the penetration of the impurities that abound in the atmosphere of most shops and plants. It is a recognized fact that the increased speeds demanded of bearings today present problems of lubrication and dissipation of frictional heat. It is also a recognized fact that the penetration into the bearing of abrasive material, from the atmosphere, takes as great a toll from the life of a bearing as any other factor.

The first applications of an oil mist principle of lubri-

cation were utilized when an air line oiler was applied to the air lines supplying pneumatic tools. However, the oil mist generated by an air line oiler varied uncontrollably in oil mist particle size. In fact, 94 to 96 per cent of the mist generated was of so large a particle size that it readily collected on the walls of the conveying pipe or tubing. This fact prevented equitable or controlled distribution of the oil mist to more than one point of application.

Present day oil mist lubricator design has eliminated this problem and now about 96 per cent of the mist generated is of a particle size two to five microns in diameter that can be distributed and controlled.

The fact that oil can be converted to mist and conveyed reasonable distances through pipes of suitable size, without any marked precipitation effect, and then can be reconverted to liquid oil at will by passing for short distances, through small bore holes, gives considerable control over its application for the solution of lubrication problems.

It presently is reported to be doing an adequate job of lubrication on the work roll bearings and large back-up roll bearings on mill stands in the steel and aluminum mills and is doing an outstanding job in preventing the contamination of the rolling oils and solutions.

"A PRACTICAL APPROACH TO A FUEL AND LUBRICATION PROBLEM"

by C. R. BURTON, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Div., United States Steel Corp., Hibbing, Minn.

C. R. BURTON

▲ PROPER lubrication of mobile mining equipment working in scattered operations presents a problem.

The first step in a solution to this lubrication problem was the consolidation of the number of oils and greases used. The second step was the training of persons responsible for lubrication in the where and when of lubrication.

The third step in the solution to this lubrication problem was the installation of a control laboratory for the testing of lubricants and fuels in use in the equipment as well as new products. The control utilizes test engines as well as laboratory techniques as an aid in this evaluation.

This three-step program has been a help to the equipment operator, the repairman, and management.

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Figure 1 (left)—Workmen position 2 x 6-in. spokes around the hub after flat has been rammed in, and then 1 x 6 in. facing boards are tacked into place to box the form

for the first level of ramming mix. Figure 2 (right)—Workmen tamp in the top layer of mix. In bigger furnaces, decking could be provided for work platform.

STEEL HUB FORMS REDUCE TIME FOR INSTALLING ELECTRIC FURNACE RAMMED HEARTHS

▲ INSTALLATION of rammed hearths in electric furnaces no longer has to be a tedious, time-consuming job. A steel hub form offered to arc furnace operators by Basic Refractories, Inc., Cleveland, takes the drudgery out of the task and produces a monolithic structure that leaves more usable hearth area.

Ramming is done vertically in back of the form, giving greater uniformity and density to the banks. Thickness and slope of the banks may be closely controlled to the contour best suited to the steelmaking needs.

The accompanying illustrations show construction of a hearth in a 20-ton furnace at Ohio Steel Foundry Co., Lima, Ohio. The entire job took only 6¾ hours and required 9 tons of ramming mix. Basic supplied the supervision, and the foundry supplied four laborers, a carpenter and a carpenter's helper.

First, the bottom flat is rammed into place. This done, the steel hub form is centered on the flat and 2 x 6-in. boards are fitted to it in spokelike fashion. Ends of the 2 x 6's are cut to the angle required for proper bank slope, and a facing of 1 x 6 in. boards tacked to the ends makes up the first level of the 16-sided form.

For some installations it may be desirable to vary the bank slope or thickness in some areas of the hearth. By changing the length of some of the 2 x 6 spokes and/or the angle at which the ends of these brace members are cut, just about any form contour can be achieved.

Ability to establish bank slopes precisely is particularly helpful in the tap-hole section. Depending on the height of the tap hole and the maximum pouring angle of the furnace, it may be desirable to bring the base of the back toward the center of the furnace and flatten out the slopes. Proper design will insure complete furnace drainage.

The ramming mix is shoveled into the space between the form and the brickwork and compacted by vertical ramming up to the top of the facing boards. The next set of 2 x 6 spokes is joined to the bottom layer with 1 x 4-in. scab boards. These spokes can either be short as shown in the photos, or long enough to brace against the hub for added strength in large furnace installations.

Use of longer 2 x 6's has another advantage. A decking can be laid over the hub and spokes, providing a good working platform.

After the facing boards are added, the next layer of mix is rammed in place. This cycle continues until either the desired height is reached or lack of clearance makes further use of forms impractical. In the latter event, tamping above the forms should be done with the rammer as near vertical as possible.

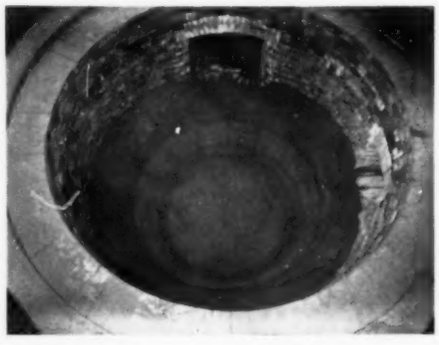
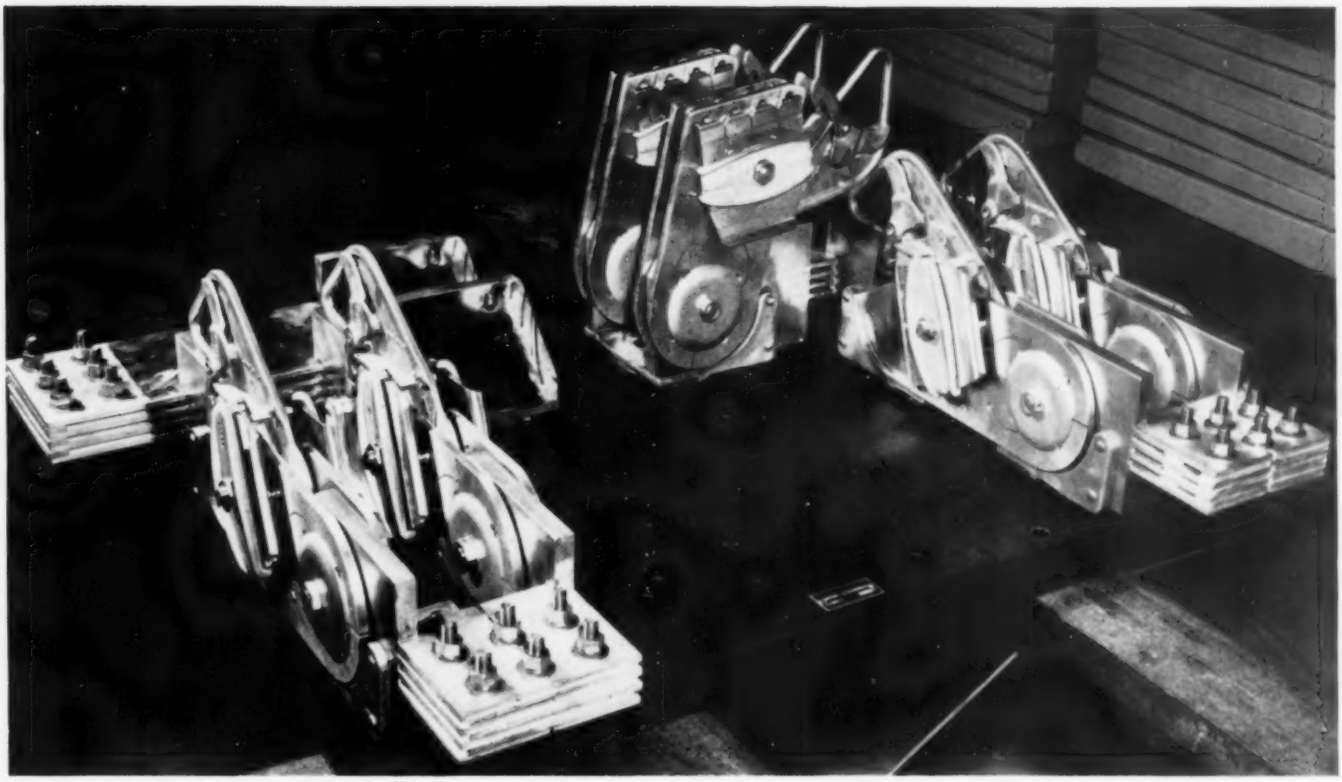


Figure 3 — It took only 6¾ hours to complete the hearth. Note monolithic lines of finished job.

In the Ohio Foundry furnace, banks were rammed five boards high and carried to a feather edge about 4 in. above the last form board. The furnace was ready for use immediately after the lumber and steel hub were removed.

Basic Refractories credits personnel at the Canton, Ohio, plant of Republic Steel for many of the suggestions that have perfected the system. The technique was first tried out on one of Republic's furnaces.



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The special indoor disconnect switches shown above were designed specifically to solve a problem of by-passing and disconnecting heavy power loads. They are basically Delta-Star's unit-type single pole 6000 ampere, 600-volt J-14P Disconnects mounted on a common base. The special switch design also solved a limited space problem.

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"We eliminated Motor Burnouts and cut new installation costs – by using Fusetron dual-element Fuses!"

"Our organization services some 43 Alfalfa Mills in the central Nebraska area.

"We know, from experience, that overloads and single phasing are two of the most common causes for motor failures in these mills.

"In order to give these motors the protection they need, we use Fusetron fuses in motor-running protection sizes. As a result, we have eliminated motor burnouts for our customers.

"In addition, on new installations, we have found that smaller switches can be used with proper size Fusetron fuses.

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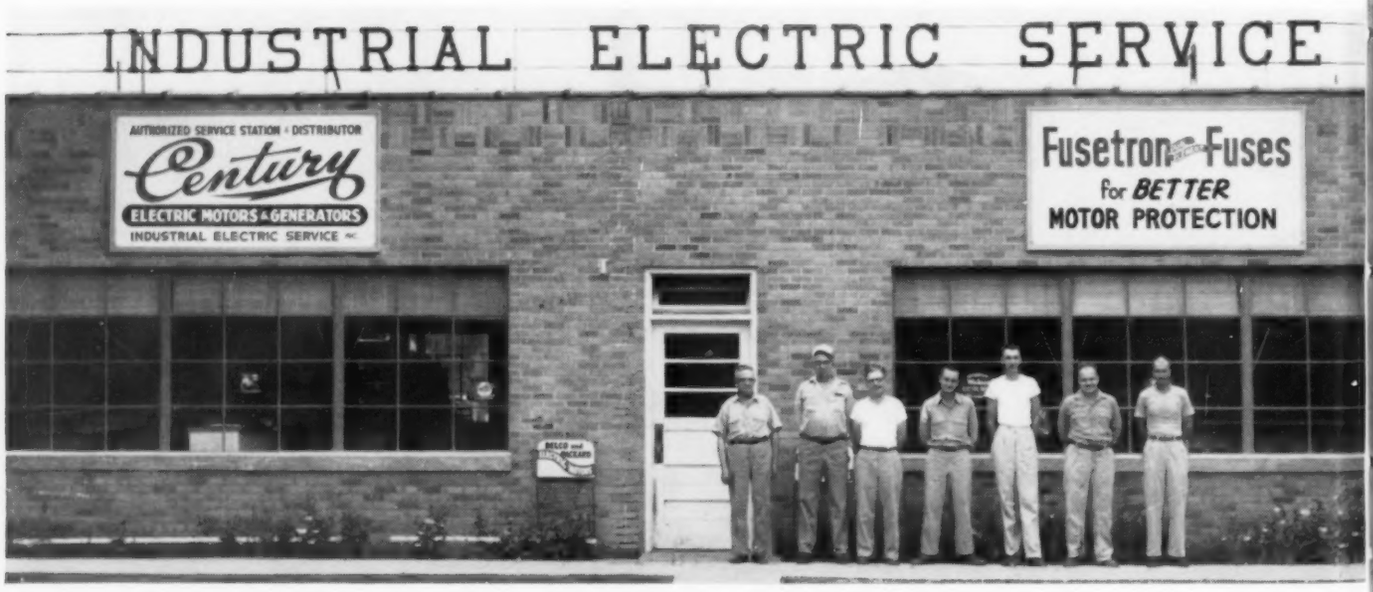
Max T. Moore, Vice-President
Industrial Electric Service, Inc.
Kearney, Nebraska



Here's why Fusetron dual-element fuses give DOUBLE protection to large motors

Of course, large motors are protected with thermal cutouts or overload relays. But experience has shown that such devices sometimes stick or fail to operate. When they do, the motor burns out.

On normal installations, by replacing fuses used for short-circuit protection with Fusetron fuses of motor-running protection size, you get the same short-circuit protection PLUS double protection against motor burnout from overload or single phasing.

If thermals or relays fail to operate for any reason, the Fusetron fuses will act independently to SAVE THE MOTOR.

And Fusetron fuses protect against waste of space and money — permit use of proper size panels and switches.

On motor circuits Fusetron fuses can be used in sizes near to the operating load. That cannot be done with ordinary fuses. It is possible with Fusetron fuses because they have a tremendous time-lag that prevents them from opening on starting currents or other harmless overloads.

This means that on new installations for motor circuits you can save space and money because *proper* size Fusetron fuses permit using *proper* size switches and panels instead of *oversize.*

You too, can profit by the 10 point protection of Fusetron fuses

1. High interrupting capacity — protect against heaviest short-circuits. Have proven on tests to open safely on circuits set to deliver in excess of 100,000 amperes.
2. Protect against needless blows caused by excessive heating — lesser resistance results in cooler operation.
3. Protect against needless blows caused by harmless overloads.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. **Protect against waste of space and money — permit use of proper size switches and panels.**
6. **Protect motors against burnout from overloads.**
7. **Give DOUBLE burnout protection to large motors — without extra cost.**
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For more information on Fusetron fuses write for bulletin FIS.

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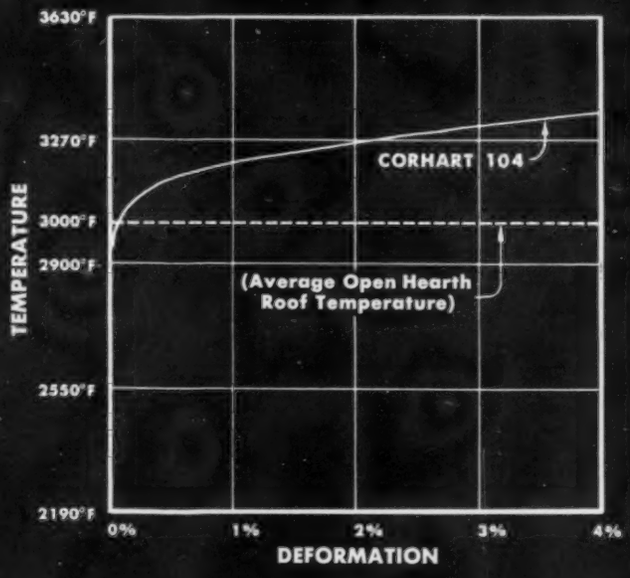

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Cast Stainless Equipment Speeds Pickling Operations

▲ ONCE a laborious and inexact hand operation, pickling of ferrous and nonferrous mill products has in recent years become a high speed and efficient operation, capable of being placed in a continuous production line along with rolling mills, annealing furnaces and automatic milling machines. This transition was possible in the post war expansion period because of the availability of stainless pumps, flanges and valves, which could handle highly corrosive pickling solutions.

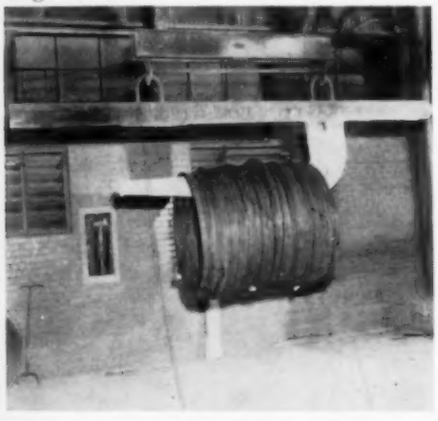


Figure 1 — In pickling stainless steel wire in a mid-western wire mill, wire coils are supported by a type CN-7M cast alloy hook; three smaller hooks are shown in the foreground.

The following case history illustrating stainless components in pickling mechanization is from a survey conducted by the Alloy Casting Institute.

Pickling of specialty mill products such as stainless steel wire and strip offers a particularly difficult problem because of the extremely corrosive nature of the pickling and cleaning solutions. For instance, in the pickling of stainless steel wire, solutions used include nitric-hydrofluoric acid mixtures, nitric acid, sulphuric acid, and special descaling salt solutions. Depending on the composition of the stainless wire and final properties desired, the pickling solutions are kept at various elevated temperatures. To support the wire during pickling and cleaning operations, many steel mills utilize pickling "hooks" (Figure 1) cast in type CN-7M stainless alloy. Because of its high resistance to the corrosive solutions, this stainless alloy assures long life for the casting. The complex shape of the hook, and the severe service to which it is exposed, make integral cast construction more economical than fabrication by other methods.

At the Pennsylvania plant of a leading steel producer, silicon steel strip for electrical applications and stainless steel strip for a wide variety of applications, are pickled in continuous strip picklers, in which the steel is fed as an endless ribbon through degreasing, rinsing, acid pickling and rinsing tanks, to remove mill scale and metallic oxides. Each of the two types of products—the silicon strip and the stainless strip—are handled in separate pickling setups, but single-stage centrifugal pumps of the horizontal end-suction type, made of cast type CN-7M stainless alloy, handle all of the acid, from the original storage stage through the disposal of spent acid.

In the silicon strip pickling process, 10 per cent sulphuric acid, mixed in the plant, is employed at 180 F. Concentrated sulphuric acid is unloaded from tank cars and delivered to storage by type CN-7M alloy pumps and valves. From storage it flows by gravity into the pickle tanks where it is diluted to the required concentration. After the pickling is completed, the spent acid is pumped into a gravity sewer leading into a collecting tank. Type CN-7M alloy

Figure 2 — To recirculate spent pickling acids and milk of lime in neutralizing tanks, type CN-7M alloy pumps and valves are used.

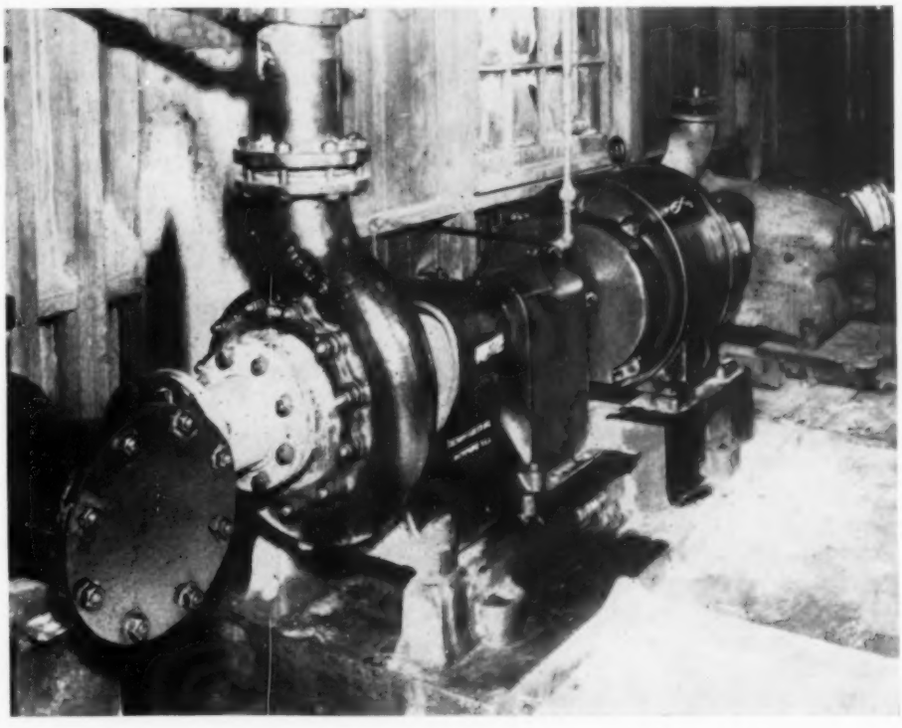


TABLE I

Standard Designations and Chemical Composition Ranges for Cast Corrosion Resistant "18-8" Alloys

Cast alloy designation	Wrought alloy type*	Composition — per cent							
		C max	Mn max	Si max	P max	S max	Cr	Ni	Other elements
GF-8	304	0.08	1.50	2.00	0.04	0.04	18-21	8-11	.....
CF-8M	316	0.08	1.50	1.50	0.04	0.04	18-21	9-12	Mo 2.0 - 3.0
CN-7M	....	0.07	1.50	**	0.04	0.04	18-22	21-31	Mo-Cu**

*Note: Wrought alloy type numbers are listed only for the convenience of those who want to determine corresponding wrought and cast grades. Because the cast alloy chemical composition ranges are not the same as the wrought composition ranges, buyers should use cast alloy designations for proper identification of castings.

**There are several proprietary alloy compositions falling within the stated chromium and nickel ranges, and containing varying amounts of silicon, molybdenum and copper. Such alloys are available from licensed producers only.

pumps handle the sulphuric acid at every stage.

In the pickling of stainless steel, the concentrated acid flows by gravity from the storage tank to the pickling tanks where it is mixed to form a solution of about 1 per cent hydrofluoric and 3 to 4 per cent nitric acid, which is used at 150 F. The spent mixture from the "stainless unit" pickling tanks is pumped to the common collecting tank, into which is also pumped spent acid from the silicon steel pickling tank. This mixture is then pumped to another tank in which a neutralizing milk of lime solution is added. Alloy pumps (Figure 2) and valves are also used to recirculate the acid and milk of lime mixture in the neutralizing tanks. The "neutralized" mixture is then pumped by a cast iron pump to a dumping area.

Eight pumps made of type CN-7M alloy were installed starting in 1943. It has been estimated by the company's engineers that maintenance costs of repair parts in the intervening twelve years have been about equal to the costs of two new pumps. As a rough estimate, these engineers state that life of alloy parts in acid neutralizing service is about ten years. In the opinion of both the steel company's engineers and the engineers of the high alloy foundry which supplies the pumps, there is no known commercial metallic or nonmetallic material that has the same satisfactory service life as the CN-7M alloy, in contact with the severely corrosive mixture of hydrofluoric, nitric and sulphuric acids.

NEW PUBLICATION COVERS OIL AND GAS INDUSTRIES

▲ A new fact book concerning America's vast petroleum and natural gas industries has just been completed by the Bureau of Mines and now is available to those seeking authoritative information about a nationwide enterprise which has invested more than $45,000,000,000 in resource development.

Equally interesting to the layman and technologist, the publication is crammed with historical descriptions and contains scores of significant items about current production, reserves, transportation, and the many uses of petroleum and natural gas. It tells about the first tanker, first tank car, first refinery, and even discloses that the first flowing oil well actually was an unfortunate mistake.

Although the first commercial well drilled for petroleum came into production in 1859 at Titusville, Pa., one David Beatty accidentally created an oil well in Kentucky some 40 years earlier while drilling into a brine formation for salt. The unwanted petroleum that spurted forth was permitted to flow into the Cumberland River and covered the surface for 35 miles. It caught fire and caused extensive property damage along the banks.

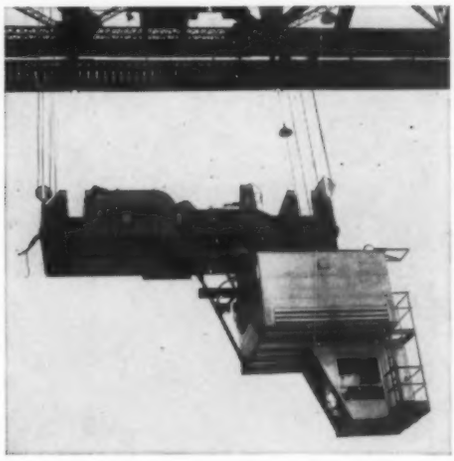
The Bureau report also shows that contrary to popular impression, a handful of companies do not control the oil and gas industries, but that more than 18,000 firms are engaged in exploration, drilling, and production. In addition, many thousands of business establishments are involved with refining, transportation, and marketing.

Considered a must as a reference publication in libraries, the Bureau's report was many months in preparation by its top authorities in the fields of petroleum and natural gas.

Copies of the publication, known as the "Petroleum and Natural Gas" portion of Bulletin 556, "Minerals Facts and Problems," can be obtained only from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. It costs 40 cents a copy. The publication is not for sale by the Bureau of Mines.

"Minerals Facts and Problems," which will contain 87 chapters on the mineral industry of the United States from "A" to "Z"—aluminum to zirconium—will be ready in a few months. All its chapters, like that on petroleum and natural gas, will complete reference works on specific subjects. Eighty of the 87 chapters already have been released and are sold individuall by the Superintendent of Documents.

you CAN double ore bridge capacity without production shutdowns!



Operating records of several steel companies prove that you can add greater ore handling capacity practically and economically. In recent years, these companies installed Dravo replacement man trolleys on their existing bridges and immediately realized these benefits: Increased free-digging hourly tonnage rates (in one case, doubled), faster operating cycles, no blast furnace shutdowns since installation took less than 24 hours! Most important, this greatly improved performance was obtained at ⅛ the cost of a new bridge.

Take a close look at your present ore bridge operations—then let a Dravo engineer show you the big difference a Dravo replacement man trolley will make in its performance. For full details on this—and other time-saving, cost-cutting Dravo material handling systems—call, wire or write Dravo Corporation, Neville Island, Pittsburgh 25, Pa. SPalding 1-1200.

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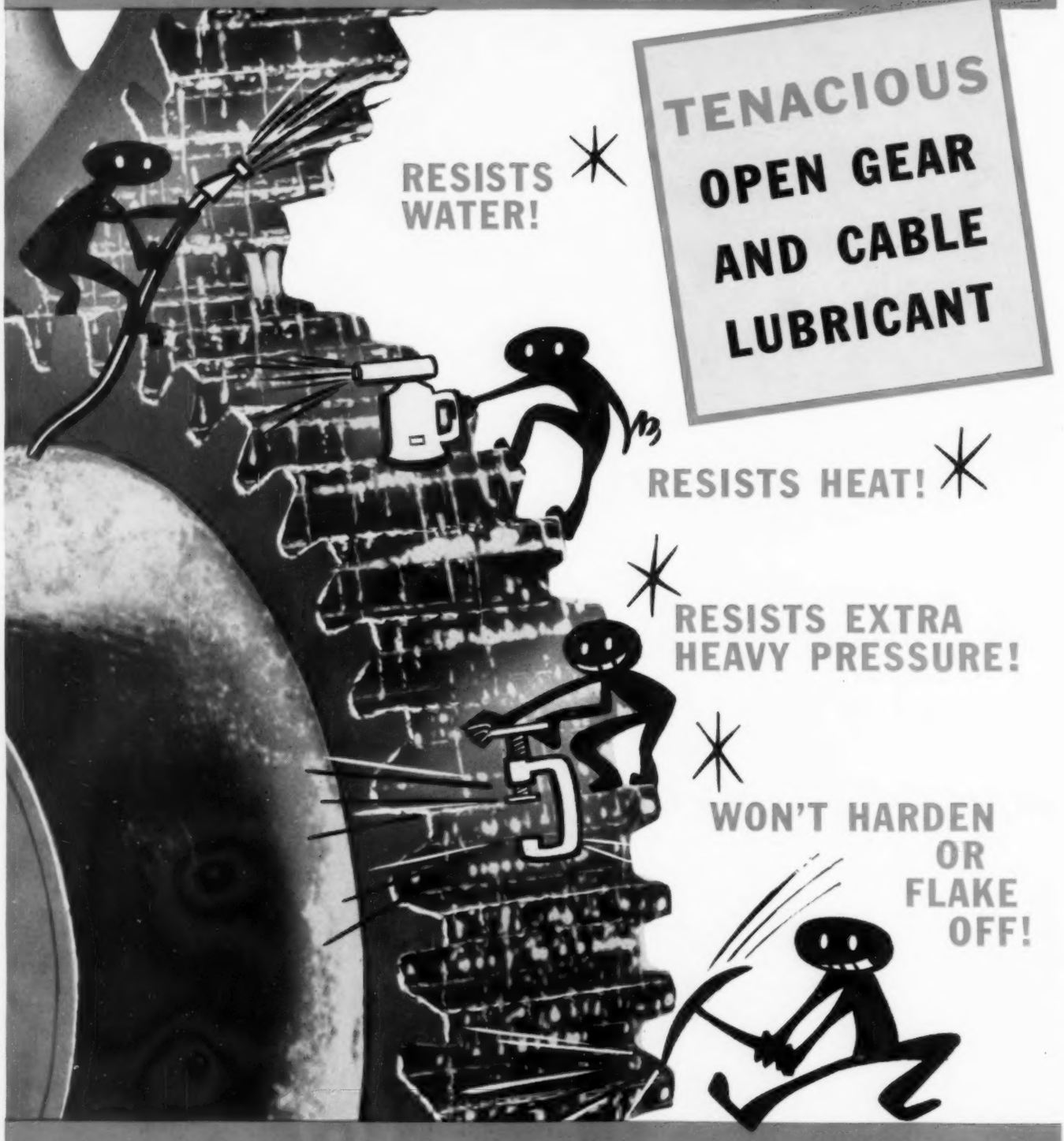
DESIGNERS and BUILDERS

Bridges and Unloaders . Tower-type Unloaders
Whirler Cranes . Floating Cranes
Dravo Rail Clamps . Barge Shifters
Modernized Trolleys for Existing Bridges

HOUGHTON'S TENAC



TENAC REDUCES LUBE COSTS BECAUSE IT LASTS LONGER!

adheres to gears longer under **tough** conditions!

Stand-Out Advantages of this Free-Flowing, Fast-Setting Lubricant Make it Ideal for Your Heaviest Gear and Cable Applications . . .

• EASY APPLICATION—

Use brush, swab, spray or drip feed—no pre-heating necessary.

• FAST SETTING ACTION—

Tenac contains a special solvent which maintains the lubricant in a fluid condition in storage. The solvent evaporates after application and the lubricant quickly jells into a tough, elastic film.

• HIGH FILM STRENGTH—

Tenac lubricating film is tough and durable. It will not separate or become brittle under high pressure or constant gear action.

• LONG-LASTING PROTECTION—

Even after extended periods of heavy duty service, Tenac continues to provide a tightly-clinging neutral film that will not expose metal surfaces. And its resistance to water helps prevent rust or corrosion.

• HIGH FLASH POINT—

The flash point for Tenac is far higher than that of similar lubricants. This reduces solvent evaporation and provides greater safety in reducing the fire hazard.

• PASSES "FOUR GRAM" TEST—

Approved by "Four Gram Retention Test" where a Timken test cup and block set-up is operated under a 43-pound lever load at 800 RPM.

• FOR ALL OPEN GEARS AND CABLES—

Tenac Lubricants—Light, Medium and Heavy —are recommended for all open gears and cables of such equipment as presses, shovels, hoists, elevators, shears, overhead cranes and all drives where conditions do not permit enclosure.

For more detailed information on how Tenac can reduce your lubricant costs call your Houghton Man or write to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

AVAILABLE IN 3 GRADES

- **Tenac L . . . . Light**
- **Tenac M . . . . Medium**
- **Tenac H . . . . Heavy**

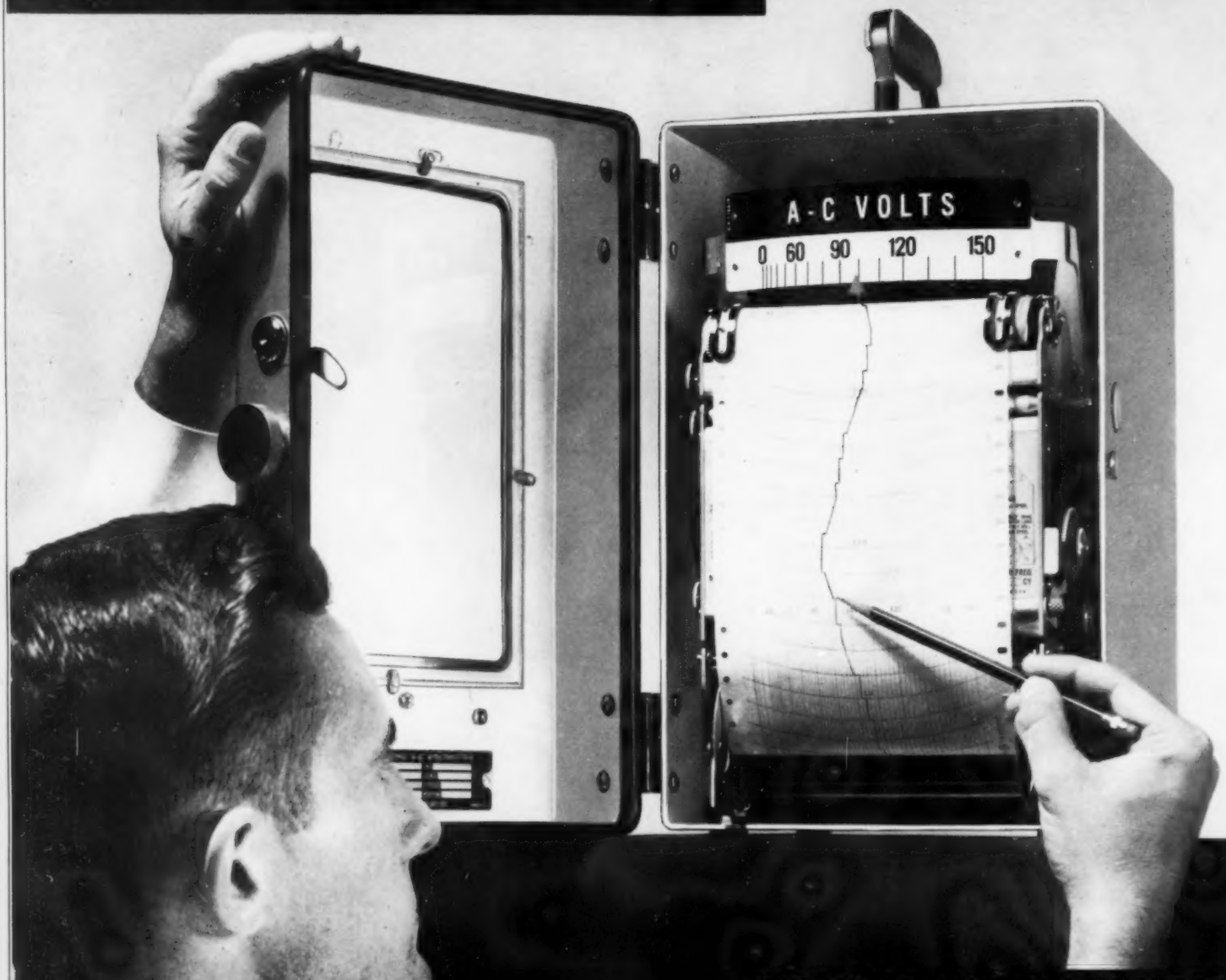
TENAC ... A PRODUCT OF

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Instruments for Productive Maintenance



VERSATILE NEW G-E RECORDER

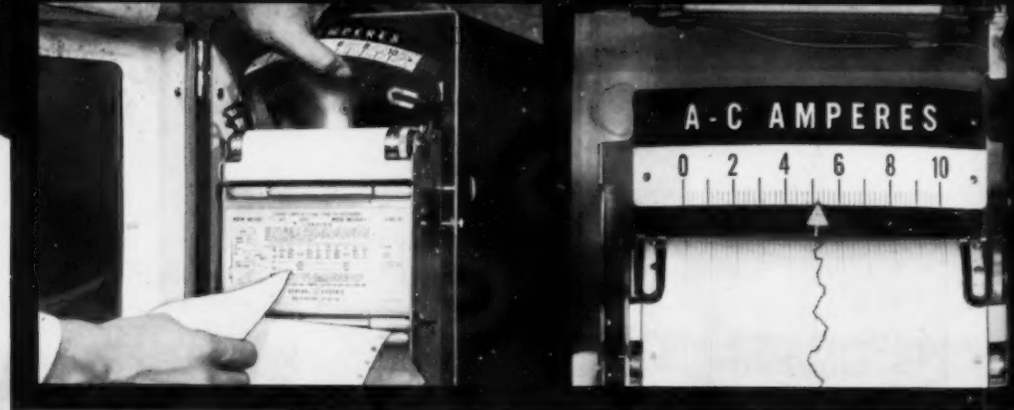


CHART SPEEDS from ¼ inch per hour to 120 inches per minute are standard on the double-speed, motor-driven chart carriage. Speeds are set by using simple instructions on the front of the carriage.

G-E RECORD ROLLS provide high color contrast between chart lines and ink. Switchboard recorders have fluorescent lamps for maximum glare-free chart illumination.

NEW General Electric Recorder Assures Sharp, Clear Records

Unique G-E Writing System Has Throw-away Inkwell; One of Six Outstanding New Cost-saving Advantages

UNIQUE WRITING SYSTEM in the new G-E general purpose recorder makes records more accurate and readable with sharp, clear pen traces. Switchboard and portable models of the new instrument can measure and record current, voltage, power, frequency or speed. Drives are synchronous motor or spring clock.

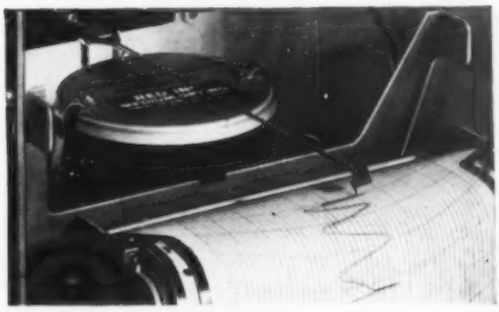
NEW THROW-AWAY INKWELL makes service quick and easy. Replacement ink comes in a sealed transparent plastic inkwell for convenient insertion. Inkwell holds a full 3 ounces, avoiding frequent replacement of ink supply.

28 CHART SPEEDS are available for more versatile recorder application. Fast, convenient changes to any one of the chart speeds may be made by simply changing color-coded gears.

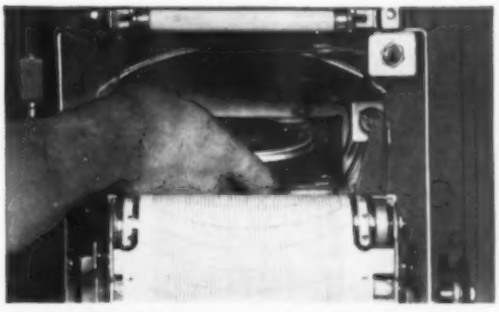
NEW G-E RECORD ROLLS are 1½ times longer than ordinary record rolls. Easier reading comes from light-green ruling in contrast with red recording ink. Faulty chart records are avoided because special paper resists shrinkage and stretching.

A 60-DAY SPRING CLOCK in G-E clock-driven models avoids the need for accessory winding devices. Hand-wound jeweled-spring clock can drive the chart for 60 days at a speed of 1 inch per hour.

NEW DESIGN makes working mechanism easily accessible. Only a screw driver and a socket wrench are needed for normal maintenance. Chart carriage takes less than 60 seconds to remove.

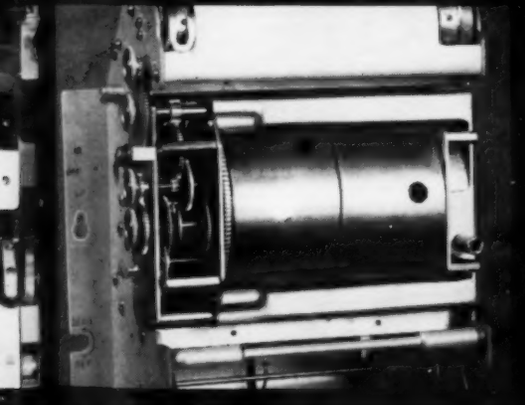


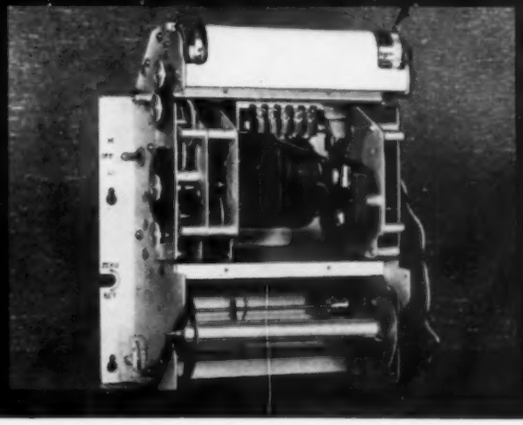
UNIQUE WRITING SYSTEM provides dependable inking with special alloy pen point, spring-loaded pen saddle, and sealed inkwell.



INK REPLACEMENT is fast and easy with sealed inkwell that slips under two spring clamps. Transparent inkwell shows level of ink.

ASSURES EASY MAINTENANCE AT LOW COST





SECTION B582-2
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, NEW YORK

Please send me the following bulletin:
GEC-1319 General Purpose Recorder, Type CH

Name.....

Company.....

Street.....

City.....Zone....State.....

HAND-WOUND SPRING CLOCK chart drives provide 60-day operation at 1 inch per hour with each winding. Chart speeds are from ¼ inch per hour to 30 inches per minute.

CHART CARRIAGE DESIGN allows all maintenance work to be done from the front of the instrument. Entire carriage may be removed in less than 60 seconds by loosening only four screws. Keyhole slots aid quick removal.

FOR FURTHER INFORMATION about the versatile new G-E general purpose recorder, contact your nearest G-E representative, or clip and mail the coupon above.

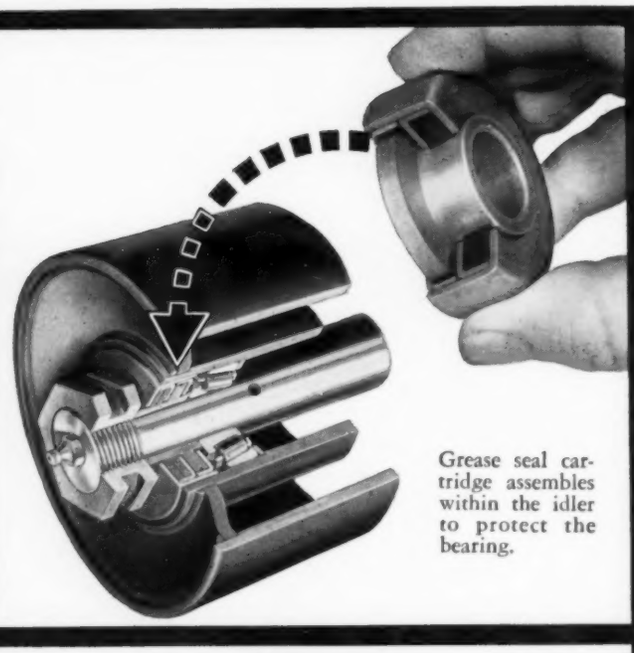
GENERAL ELECTRIC

Today's simplest IDLER GREASE SEAL is also the best-performing

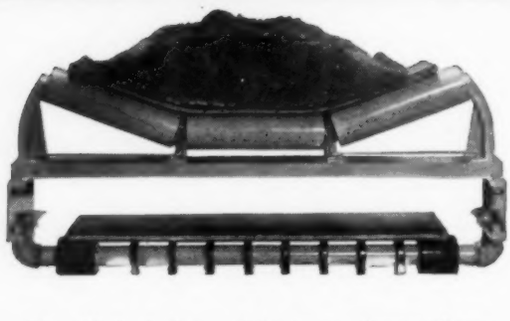
THE cartridge grease seal used on Link-Belt belt conveyor idlers provides the effectiveness of multiple sealing with the convenience of a single unit. A contact seal of laminated felt and neoprene combined with a labyrinth keeps dirt out, grease in. And the grease itself within the labyrinth further prevents entrance of dirt or other matter. What's more, no springs or loose washers are involved . . . there's no chance for metal-on-metal friction. The entire assembly comprises a rugged, compact "cartridge."

Simplicity is only one of the big advantages you get with Link-Belt idlers. Check the others below. For complete facts ask your nearby Link-Belt office or authorized stock-carrying distributor for a copy of Book 2416. It lists over 500 sizes in 34 types, including troughing, variable troughing, flat belt, belt training and rubber cushion idlers.

Sturdy, rigid frames support rolls in perfect alignment. Rolls are securely held in place but easily removed for inspection and service.



Grease seal cartridge assembles within the idler to protect the bearing.



You'll find these 6 features throughout industry's most comprehensive idler line

1 **HUSKY, HIGHEST QUALITY BEARINGS,** free and easy turning, assure maximum life, minimum belt-wear, low power consumption. Concentricity is secured by unit mounting of bearings in a heavy-wall center tube.

2 **SAFE, CONVENIENT GREASE FITTINGS** protected by flange ribs of support brackets provide ease of lubrication—lubrication for longer life.

3 **CONCENTRIC ROLLS** have smooth surfaces and rounded edges. Machine-made, continuous welds prevent entrance of dirt and moisture.

4 **HOP-FREE ROTATION** is assured by close tolerances, press fits and precision assembly from shaft to shell.

5 **STRONG, RIGID FRAMES** support rolls in perfect alignment. Rolls are securely held in place but can be easily removed for inspection and service.

6 **GROOVED HEX NUTS** lock into malleable brackets, creating bridge truss effect—prevent shaft rotation and bracket spreading under load.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,805

Date-line Diary...

August 1

▲ Petroleum refinery capacity in the U. S. jumped more than 400,000 barrels in 1954 to a new peak of approximately 8,500,000 barrels daily, it was reported by Bureau of Mines.

▲ The AISI reports that operating rate of the steel industry for the week of August 1 is scheduled at 94.4 per cent of capacity. This is equivalent to 2,278,000 tons compared with 2,190,000 tons one week ago and 1,527,000 tons one year ago. Index of production for the week is 141.8.

August 2

▲ Aluminum pig and ingots were boosted 1 cent and 1.2 cents a lb respectively by the Aluminum Co. of America.

▲ An agreement was finally reached between the Mine, Mill and Smelter Workers Union and Phelps Dodge Corp. calling for wage increases ranging from 11½ cents to 17½ cents an hr and expanded fringe benefits.

▲ An Interstate Commerce Commission examiner recommended a substantial increase in rail and truck freight rates for certain steels and iron products. Hurt worse would be users of sheet and strip.

August 3

▲ Reynolds Metals said it plans to spend $230,000,000 in boosting its production 270,000,000 lb to 1,100,000,000 lb of aluminum. Plans include a 200,000,000-lb primary aluminum producing plant in Kentucky at an estimated cost of $168,500,000.

▲ The total estimated payroll of the iron and steel industry for June was $298,439,000 reported the AISI, $4,000,000 above the previous record set in May. The estimated payroll for the first six months of 1955 was $1,676,279,000 or over $235,000,000 higher than for the same period last year. Total June employment was 667,100, and wage earners average hourly cost set a record $2.42 during an average 40.1-hr work week.

August 4

▲ A critical shortage of nickel resulted in a diversion of 2,000,000 lb of nickel from the Government stockpile to nickel consumers in August, reported Defense Mobilizer Flemming.

August 5

▲ The Assn. of American Railroads said the major railroads' net income for June rose to $88,000,000, an increase of 46 per cent from the like 1954 month.

▲ Soft coal output for the first seven months of 1955 totaled 255,573,000 tons, an increase of 43,489,000 tons over the same period for the previous year.

▲ An antitrust suit against ten iron and steel rollmakers and their trade association, the Roll Manufacturers Institute, has been settled through Pittsburgh Federal Court by consent judgment, it was reported by the Justice Dept.

August 6

▲ The Aluminum Association reports its primary production at 255,265,003 lb in June compared with 262,256,314 lb in May and 241,516,343 lb in the like period of June 1954.

August 8

▲ A new high in building outlays in July was set for the second straight month with nearly $4,000,000,000, 12 per cent higher than the year-ago month and 4 per cent higher than the previous month, said the Commerce Dept.

▲ The Commerce Dept. reported a decline in personal income in June to an annual rate of $301,200,000,000, off from the $301,400,000,000 in May but a sharp increase over the $286,700,000,000 in June 1954.

▲ Steel scrap prices in the Pittsburgh area rose to $45.50 a ton, up $5.50 since three weeks ago and $10.50 a ton since May.

▲ The AISI reports that operating rate of the steel industry for the week of August 8 is scheduled at 90.8 per cent of capacity. This is equivalent to 2,192,000 tons compared with 2,098,000 tons one week ago and 1,525,000 tons one year ago. Index of production for the week is 136.5.

August 9

▲ United Engineering and Foundry Co. offered $4,500,000 for a plant in New Castle, Pa. which it once operated.

August 10

▲ Employment in the U. S. soared to a record 65,000,000 in July, 1,000,000 above the preceding month and 3,000,000 higher in the like period last year, it was reported by the Commerce and Labor Depts.

▲ Reynolds Metals Co. reported a net profit of $16,425,754 or $8.07 per common share on net sales of $183,973,937 for the first six months of 1955 compared with a net profit of $9,607,766 or $4.78 per common share on net sales of $143,007,250 for the like period in 1955.

▲ The F. W. Dodge Corp. reported contract awards for future construction in the 37 states east of the Rockies set a new record in July with a total of $2,271,537,000 which was 24 per cent above July one year ago.

August 12

▲ The Commerce Dept. reported output of goods and services in the second quarter of 1955 rose to an annual rate of $385,000,000,000, up from the $375,000,000,000 in the first quarter.

▲ General Electric and the CIO International Union of Electrical Workers signed a 5-yr agreement whereby wages will be increased 3 per cent annually for the next 5 years. It did not receive the guaranteed annual wage sought.

▲ Shipments of iron and steel castings during May amounted to 1,531,000 short tons according to the Bureau of the Census, or 1 per cent above April and 38 per cent above shipments in May 1954.

August 15

▲ The AISI reports that operating rate of the steel industry for the week of August 15 is scheduled at 92.3 per cent of capacity. This is equivalent to 2,228,000 tons compared with 2,157,000 tons one week ago and 1,474,000 tons one year ago. Index of production for the week is 138.7.

▲ Continental Foundry and Machine Co. announced a 10 per cent increase in the prices of cast iron and steel rolls effective immediately.

▲ Scrap consumption in June totaled 6,102,000

gross tons compared with 6,415,947 in the previous month according to the Bureau of Mines.

August 16

▲ The steel shipping container industry, the nation's second largest user of sheet steel, reported an increase of 8.8 per cent in production during the first half of 1955 over the same period in 1954.

▲ United Engineering and Foundry Co. reported a net income of $1,183,589 or 47 cents per common share on total sales of $23,793,209 for the first six months in 1955 in comparison with a net income of $1,486,958 or 59 cents per common share on total sales of $27,246,531 for the like period in 1954.

▲ Primary aluminum production in the U. S. during July totaled 265,337,163 lb compared with 255,265,003 lb in June and 252,323,794 lb in July of 1954.

▲ The Steel Co. of Canada, Ltd. boosted the price of major steel products approximately 20 cents per 100 lb, a rise of about 3 to 4 per cent.

▲ Anaconda Aluminum Co. has formally opened a $65,000,000 primary aluminum producing plant at Columbia Falls, Mont.

August 17

▲ U. S. Steel Corp. announced an increase in mill price bases for electrolytic and hot dipped tin plate, black plate and terne plate effective October 1. The increase will be 40 cents per base box for all except terne plate which increase will be 85 cents.

▲ Deliveries of new domestic freight cars in July fell to 2192 compared to the 3015 cars in June but an increase over the 1801 cars delivered in July 1954 according to the ARCI. July orders rose to 18,007 compared to 13,365 cars in June and 883 cars in July of 1954. Backlog on August 1 rose to 42,888.

August 18

▲ The price of domestic copper was raised from 36 cents per lb to 40.

▲ The Aluminum Co. of America plans to spend $19,000,000 in aluminum foil production expansion which will increase the company's foil-making capacity by 60 per cent, or 32,000,000 lb.

August 19

▲ Copperweld Steel Co. will spend around $12,000,000 in improving its production facilities at its Warren, Shelby, Ohio and Glassport, Pa. plants.

▲ Government spending slipped $2,600,000,000 into the red during July which was a $600,000,000 larger deficit than the same month one year ago.

August 22

▲ Alcoa will begin work shortly on a $2,000,000 expansion program for primary aluminum production at its Wenatchee, Washington works.

▲ Jones and Laughlin Steel Corp. plans erection of a plant to produce cold-finished steel bars on a 31-acre industrial site purchased from American Screw Co. at Willimantic, Conn.

▲ The AISI reports that operating rate of the steel industry for the week of August 22 is scheduled at 91.4 per cent of capacity. This is equivalent to 2,206,000 tons compared with 2,176,000 tons one week ago and 1,515,000 tons one year ago. Index of production for the week is 137.3.

August 23

▲ Anaconda Co. has discovered a new property in Chile which promises to be among its greatest mines.

August 24

▲ Flood problems at Bethlehem, Pa. put a damper on operations at Bethlehem Steel Co. which may take a few weeks to get back to normal operation.

▲ A wildcat strike at Great Lakes Steel Corp. threatened a complete plant shutdown.

August 25

▲ Granite City Steel Co.'s board of directors declared a common stock cash dividend of 50 cents.

▲ Granite City Steel Co.'s profit for the first six months of 1955 amounted to $5,483,603 or $2.93 per common share.

▲ Keystone Steel and Wire Co. expects to spend $10,000,000 over the next two years to increase the semi-finished steel capacity of the company's Peoria plants by at least 50 per cent.

▲ Stockholders of Lukens Steel Co. approved a proposal to change their charter to broaden the company's scope of business thus enabling the firm to manufacture metal and non-metallic materials.

▲ The AISC reports July bookings of fabricated structural steel amounted to 366,853 tons as compared to 318,150 tons in June and 262,782 tons in July 1954. Shipments in July totaled 217,658 tons leaving a backlog of work ahead as of July 31 of 1,638,752 tons.

August 26

▲ Copper took another rise to 43 cents per lb, the second mark-up in little over a week.

August 29

▲ Soft coal will 'op $5 a ton, an advance of 30 to 40 cents, due to wage increases to United Mine Workers.

▲ Machine tool orders in July totaled $63,850,000 which was 18 per cent below June but 73 per cent above July of 1954.

▲ For the fiscal year ending June 30, 1955 Kaiser Steel Corp. reported net earnings of $5,741,236 or $1.08 per share on common stock on total sales of $136,688,126 in comparison with the previous fiscal year's net earnings of $7,926,666 or $1.75 per share on common stock on total sales of $128,883,898.

▲ The AISI reports that operating rate of the steel industry for the week of August 29 is scheduled at 93.8 per cent of capacity. This is equivalent to 2,264,000 tons compared with 2,186,000 tons one week ago and 1,525,000 tons one year ago. Index of production for the week is 140.9.

August 31

▲ Alan Wood Steel Co. has acquired the Steel Equipment Division of Penn Metal Corp.

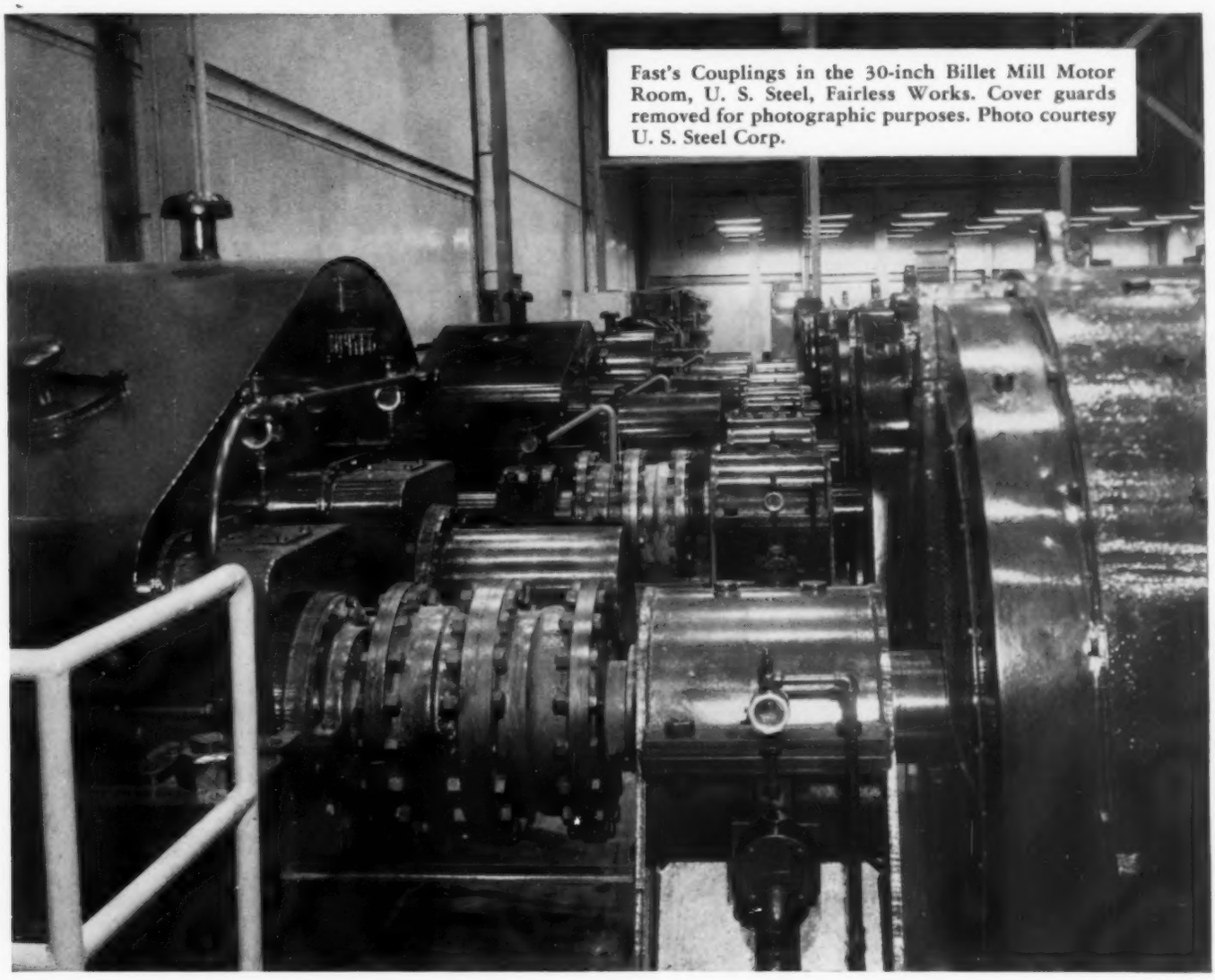
▲ The week ending August 29 showed iron ore shipments down the Great Lakes reached a new high with a total 3,164,011 gross tons, a 66 per cent increase over shipments during the like week of 1954, as reported by the Lake Superior Iron Ore Association.

▲ Copper prices on the London Metal Exchange reached an equivalent of 50 cents per lb which is 12.5 cents per lb above the level at the beginning of the year.

▲ According to the AISI, average hourly payroll cost of wage earners in the iron and steel industry in July was highest ever at $2.598 per hour compared with $2.420 in June and $2.368 in July 1954. Total payroll for wage and salaried employees was estimated at $296,857,000 compared with $298,439,000 in June. Wage earners average 35.0 hr per week (down because of vacations) and average employment was 676,400.

▲ In spite of steady production, July inventories were estimated at $43,900,000,000, only 2 per cent above the 1954 low point by the Commerce Dept.

▲ The Commerce Dept. reports corporate dividend payments during July jumped to $669,000,000, a large increase over the $543,000,000 paid in July of 1954.



Fast's Couplings in the 30-inch Billet Mill Motor Room, U. S. Steel, Fairless Works. Cover guards removed for photographic purposes. Photo courtesy U. S. Steel Corp.

U. S. Steel's Fairless Works equipped with Fast's Couplings

When U. S. Steel equipped its new Fairless Plant they selected Fast's Couplings for installation.

It's no wonder that U. S. Steel specified Fast's. Fast's Couplings have the approval of industry in general everywhere.

Industry finds that Fast's Couplings minimize down-time. Fast's, *the original gear type* couplings, give trouble-free performance. Save on maintenance. Save money (often thousands of dollars in production losses) because there is no down-time due to breakage or expensive replacement of perishable parts.

They also offer the lowest cost per year . . . usually outlast the equipment they connect. Many still in use after 30 years. Why? Because they are ruggedly constructed of the sturdiest, most practical materials . . . all steel in construction, unique in design.

35 years of experience in developing these materials and designs means our staff is well prepared to give you the most effective and cost-saving solutions to your coupling problems. Let Koppers help you. Just write, outlining your requirements. And mail the coupon below for additional general information.

KOPPERS®

THE ORIGINAL

FAST'S Couplings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. · BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.
Engineered* Products Sold with *Service

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* **219 Scott St., Baltimore 3, Md.**

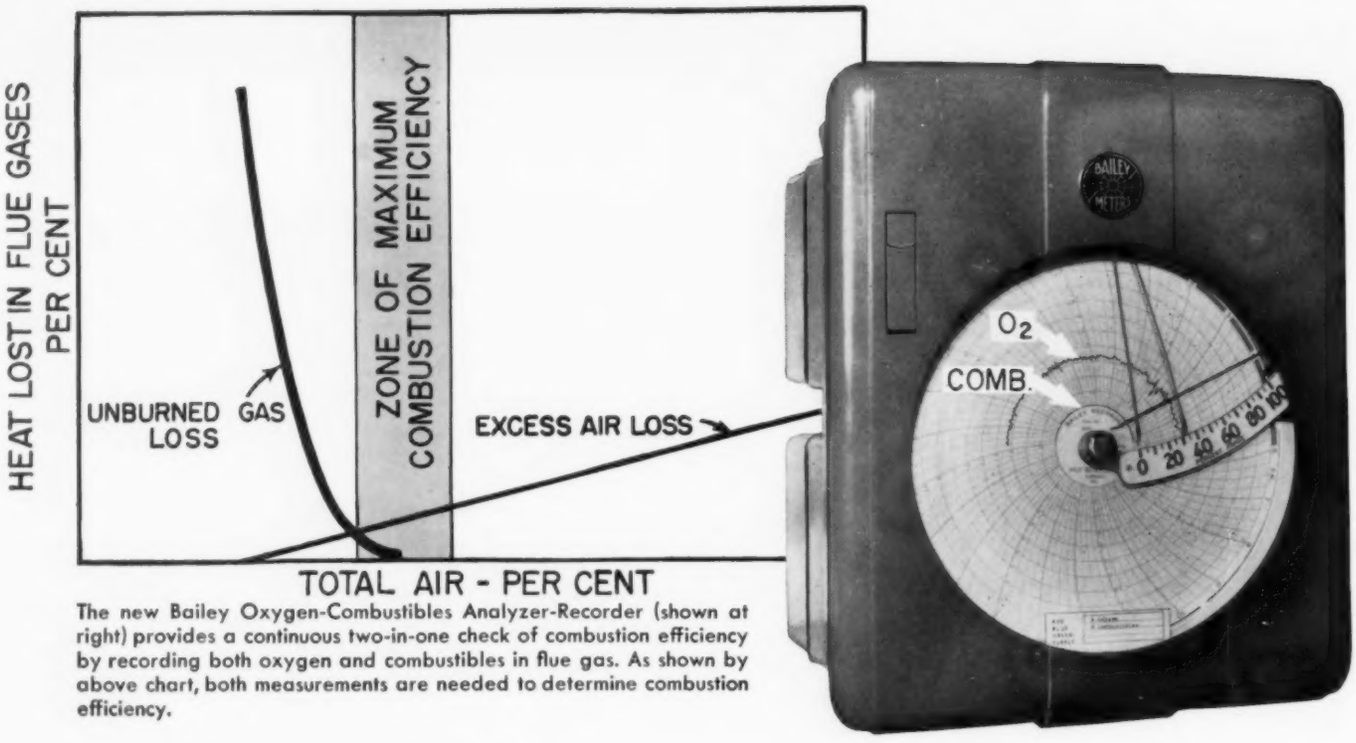
Gentlemen: Please send me a Free, Fast's Coupling Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

Company.....

Address.....

City.....Zone.....State.....



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces · · · New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. Excess air—regardless of the fuel or combinations of fuels being burned.

2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

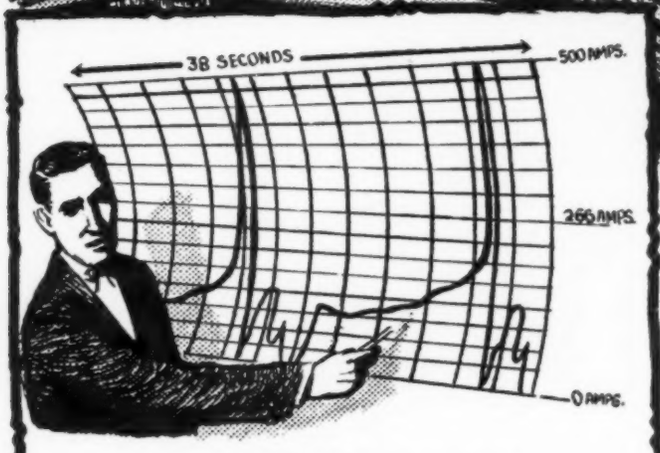
For Power And Process

FACTS ABOUT Exide®

IRONCLAD® INDUSTRIAL TRUCK BATTERIES

NO MOVING JOB IMPOSSIBLE!

STEEP RAMPS, LONG HAULS, HEAVY LOADS... NO JOB IS IMPOSSIBLE WHEN ELECTRIC TRUCKS ARE POWERED WITH IRONCLADS. EXIDE MAKES BATTERIES WITH ADEQUATE CAPACITIES TO KEEP TRUCKS WORKING FULL-SHIFT...WITH NO LET-DOWN IN TRUCK POWER OR PERFORMANCE. USER COST RECORDS SHOW THAT EXIDE-IRONCLADS ARE YOUR BEST POWER BUY— AT ANY PRICE!

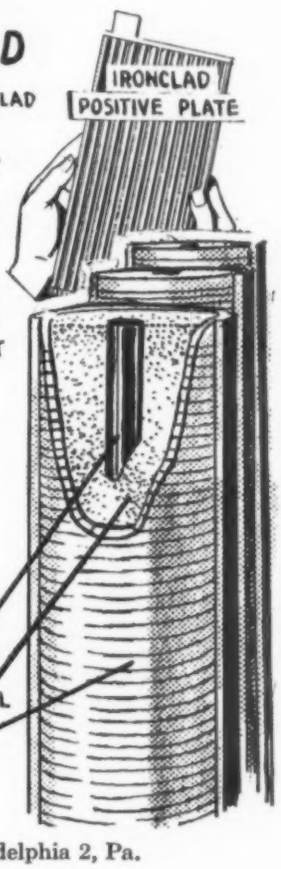


PORTRAIT OF AN EXIDE WORKING

IN JUST TWO MOVES AND 38 SECONDS A FORK TRUCK MAY DRAW ENERGY FROM ITS BATTERY IN THIS PATTERN, IN RESPONSE TO 44 SEPARATE CONTROLLER OPERATIONS. IN AN 8-HOUR SHIFT, 3000 SUCH DEMANDS MAY BE MADE. EXIDE-IRONCLADS ASSURE RAPID, ACCURATE HANDLING OF MATERIAL... THEY RESPOND INSTANTLY TO THESE RAPIDLY RECURRING DEMANDS FOR HIGH POWER FOR SHORT DURATIONS.

TUBES OF POWER WORK FOR YOU INSIDE AN IRONCLAD

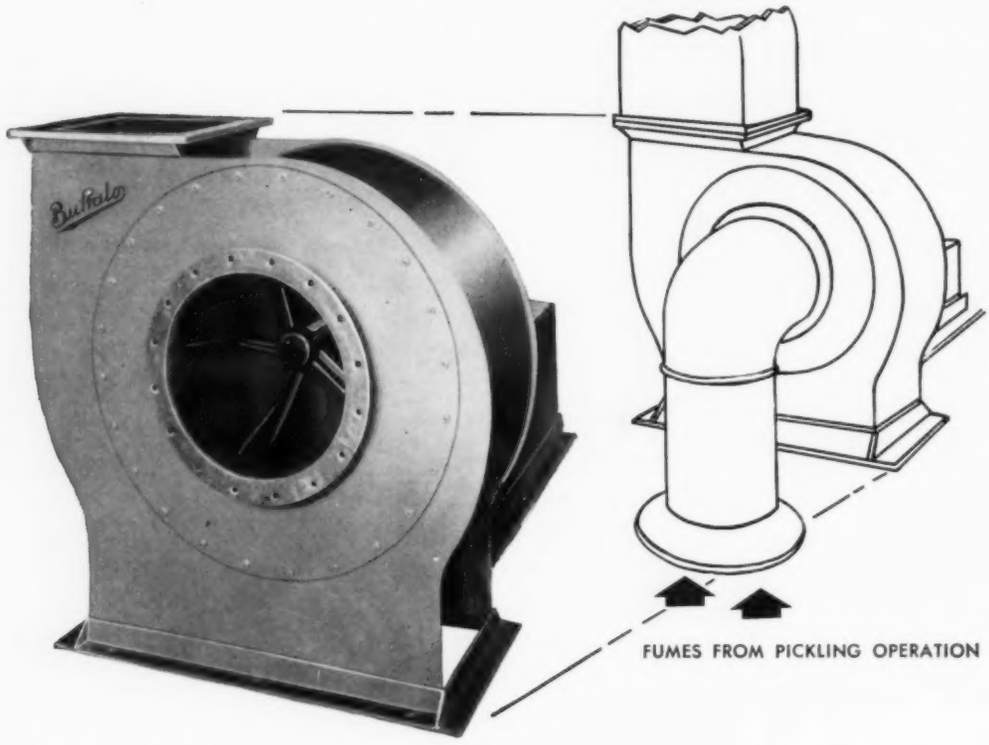
SLOTTED TUBES INSIDE AN IRONCLAD KEEP ACTIVE MATERIAL IN FIRM CONTACT WITH CONDUCTING GRIDS OF THE POSITIVE PLATE...THIS GRID PROTECTION LENGHTENS THE LIFE OF THE BATTERY. SLOTTED TUBES EXPOSE MORE ACTIVE MATERIAL TO THE ELECTROLYTE... FOR GREATER POWER. FINE TUBE SLOTS HOLD MATERIAL IN CONTACT WITH GRID LONGER...RESULT, THE IRONCLAD'S ABILITY TO DO YOUR MATERIALS MOVING JOB FOR A LONGER PERIOD OF TIME. THAT IS WHY EXIDE-IRONCLADS ARE YOUR BEST INDUSTRIAL TRUCK BATTERY BUY— AT ANY PRICE!



LET EXIDE HELP SOLVE YOUR INDUSTRIAL TRUCK BATTERY PROBLEMS. ❶ CALL AN EXIDE SALES ENGINEER FOR FULL DETAILS. ❷ WRITE FOR FORM 1982, A MANUAL ON INSTALLING AND MAINTAINING MOTIVE POWER BATTERIES.

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

WHY "PICKLE" THE EXHAUST FAN, TOO?



MAKE IT A "BUFFALO" RUBBER-LINED EXHAUSTER AND SAVE REPLACEMENTS

Actually, an ordinary metal exhauster handling pickling fumes is getting a continuous pickling — without rinsing and washing. These fan-eating fumes cause all-too-frequent expenses where they hurt most — in exhauster replacements.

"Buffalo" Rubber-Lined Exhausters are not new — they've been giving 3 to 12 times longer fume-handling service for the past 25 years. Whatever corrosive fume you handle, it never touches metal — because a protective rubber blanket is vulcanized to every square inch of the inside of the fan. "Buffalo" Rubber-Lined Fans more than pay for their extra cost in fan replacements, without beginning to count reduction of down-time. WRITE FOR BULLETIN 2424-E and see the many "plus" features that add up to the famous "Buffalo" "Q" Factor*, or extra value.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

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PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

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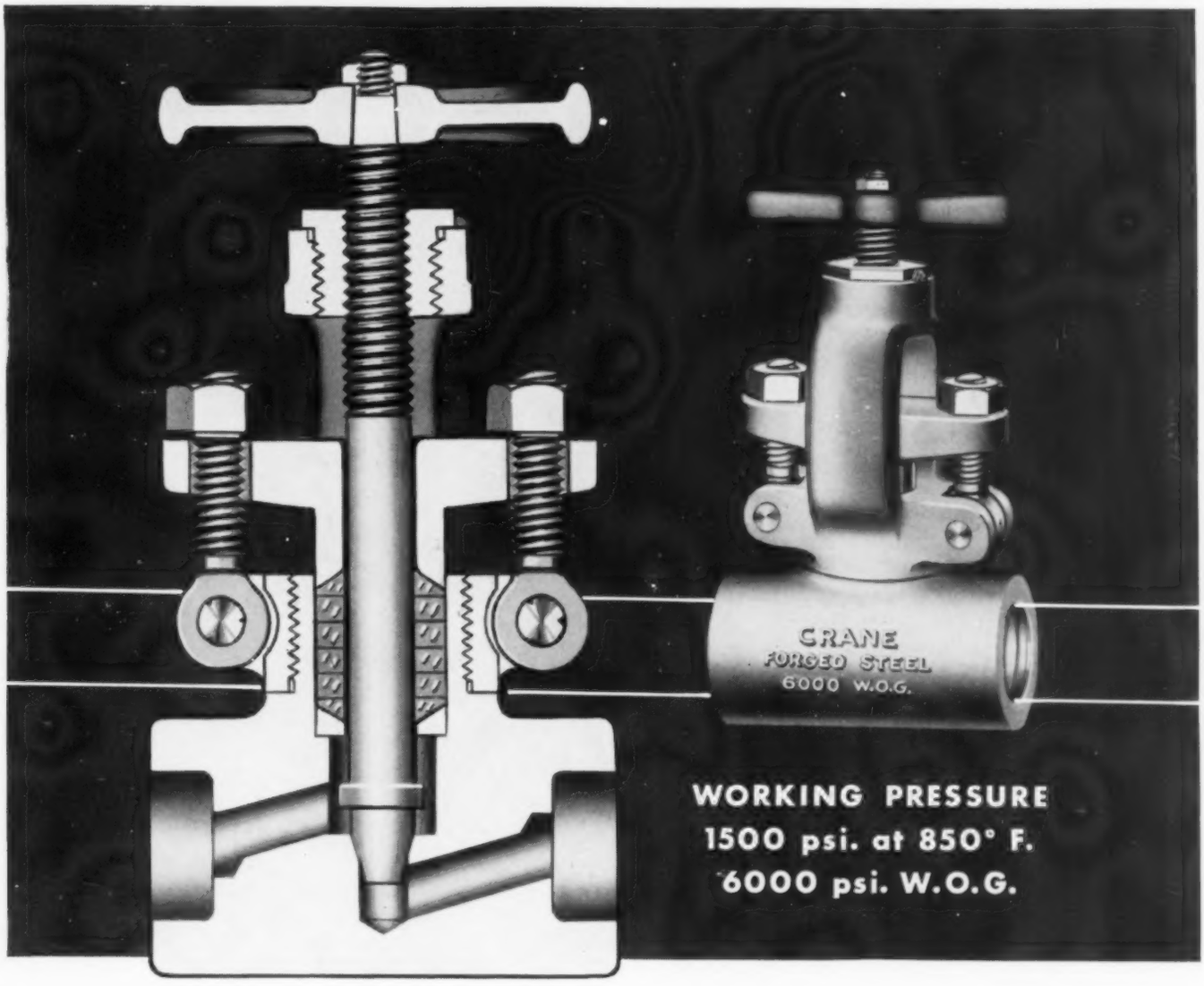
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Now Available



New Crane Forged Steel Instrument Valves

Been looking for an exceptionally rugged, compact, and low-priced stop valve for your small hydraulic or high-pressure, high-temperature instrument lines?

Crane has developed it—sizes ¼", ⅜" and ½", in both screwed and socket-welded patterns. It's the all-new Crane Forged Steel Instrument Valve, and you can specify it now for immediate delivery.

Will Handle Many Services

Note closely the over-all design and construction shown above of this new Crane valve. Oversized stuffing box—heavy-duty Crane Exelloy stem with integral disc—bolted gland—swinging gland eye bolts—outside screw and yoke construction—all add up to the high performance and low maintenance you want in a valve for your instrument panels, orifice meters, bypass and gauge lines, regulator leads, and other hydraulic and high pressure/temperature lines.

Literature on Request

These rugged, low-cost stop valves are built for 1500 psi. at 850° and 6000 psi. W.O.G. Construction and materials are job-engineered by Crane experts—backed by a century of quality manufacturing, matchless experience. You'll want complete information on the all-new Crane Forged Steel Instrument Valves. Contact your Crane Representative, or write to Crane Co., General offices, Chicago 5, Illinois—Branches and Wholesalers serving all industrial areas.

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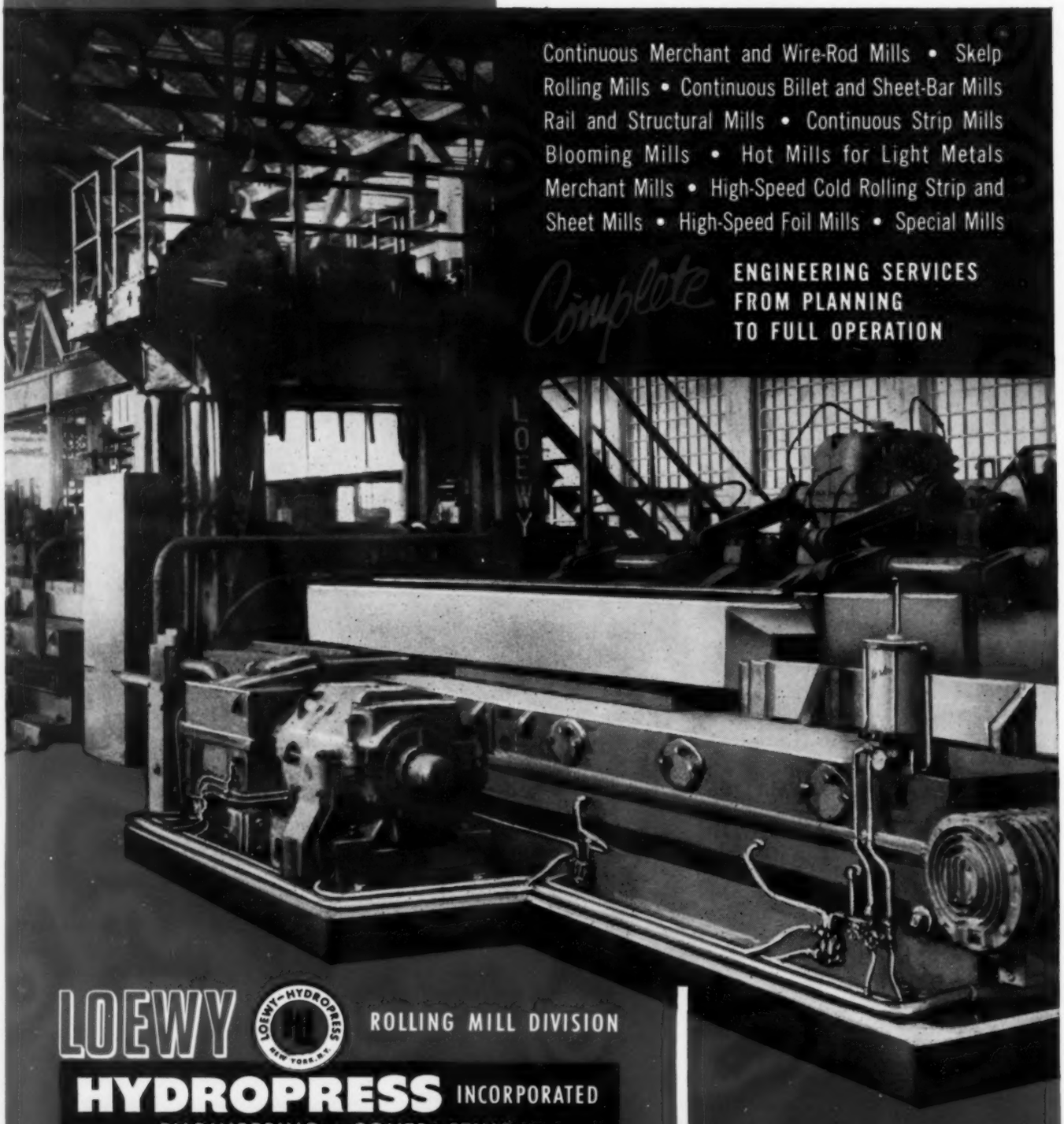
CRANE'S FIRST CENTURY...1855-1955

LOEWY ROLLING MILLS

AND ROLLING MILL EQUIPMENT FOR
STEEL, LIGHT METALS, COPPER AND BRASS



Continuous Merchant and Wire-Rod Mills • Skelp Rolling Mills • Continuous Billet and Sheet-Bar Mills Rail and Structural Mills • Continuous Strip Mills Blooming Mills • Hot Mills for Light Metals Merchant Mills • High-Speed Cold Rolling Strip and Sheet Mills • High-Speed Foil Mills • Special Mills

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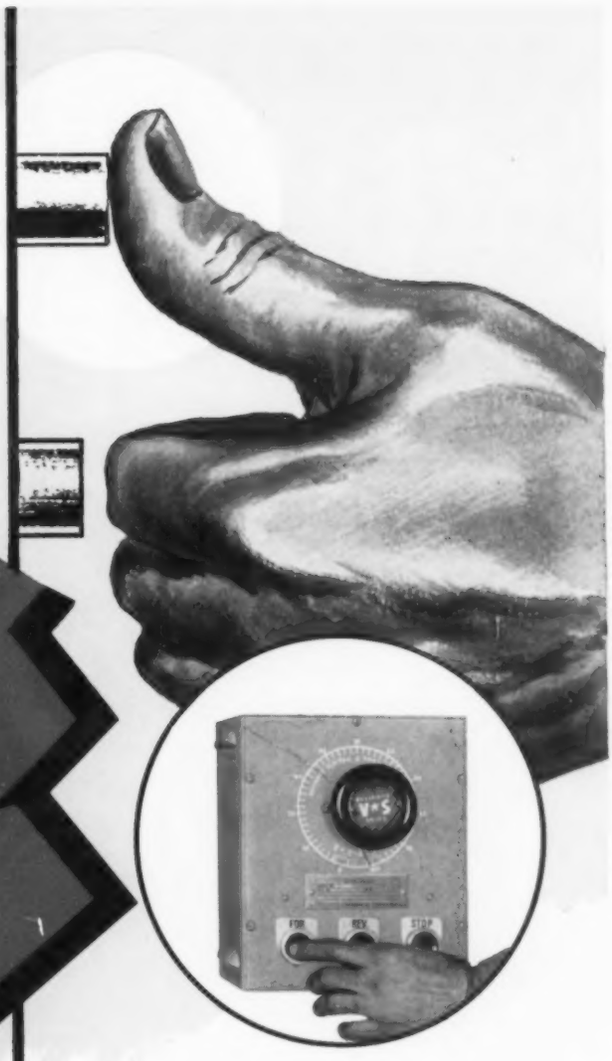
36" Two-High Reversing Mill with Electric Screw-Down. Manipulator in Front of the Mill. Part of a Complete Blooming, Slabbing, Structural and Strip Mill Installation.

Rolling Mills • Hydraulic Presses • Pipe Testing Machines • Special Pipe Mill Equipment • Accumulators • Pumps

Everything's under control...

with the

RELIANCE V★S DRIVE ®



Smooth, versatile Reliance VARIABLE SPEED DRIVES are made to help you keep *everything under control!*

Dynamic response for rapid starting, stopping and reversing; hairline accuracy for maintaining required line speeds; positive, step-by-step assurance of optimum speeds during each processing cycle; precise delicate regulation of quantity, quality, color, shape, form and size . . . in fact, EVERYTHING is precisely controlled by Reliance V★S Drives.

For faster line speeds, smoother acceleration and deceleration, more sensitive tension control and other outstanding production dividends in *your* plant, call the nearest Reliance sales office . . . or write for Bulletin D-2311. *Reliance Electric & Engineering Co., 1084 Ivanhoe Road, Cleveland 10, Ohio; Canadian Division—Welland, Ontario.*

D-1498

RELIANCE ELECTRIC AND ENGINEERING CO.

POLE STAR
DISTRIBUTION TRANSFORMERS

soon available in sizes

5-10-15-25 Kva • without taps
2400 Volts through 14,400 Volts

here ARE THE 7 PERFECT SEALS MADE BY METALLIC FUSION

In recent years, there has been a decided trend toward completely-sealed transformers. Many present-day power and network transformers are manufactured with welded covers and soldered bushings. Up to now, however, true sealed construction has not been applied to pole-type distribution transformers. Although the various methods of bolting and clamping covers and handholes can produce effective seals at the factory, when transformers are opened by the user there is no way of accurately determining if the transformer is again perfectly sealed. A half-turn of a nut or screw can destroy an effective seal and allow restricted breathing. This permits moisture to be drawn into the tank, where it becomes condensed and remains to possibly weaken the dielectric strength of the windings and oil. Failure of the transformer can result.

To correct this situation, Pennsylvania Transformer Company engineers have developed the Perfect Seal POLE STAR, a no-tap transformer which is completely and perfectly sealed to provide permanent protection to the transformer. All openings between cover and tank and between bushings and cover are permanently sealed by metallic fusion. Complete electrical tests are made to certify the performance of each transformer. Thus, there is no need for opening the Perfect Seal POLE STAR for inspection or testing prior to placing it into service.

Tooling and preparations for production are now being made, and Pennsylvania Transformer Company anticipates that Perfect Seal POLE STAR transformers will be available in a few months.

Pennsylvania Transformer Company

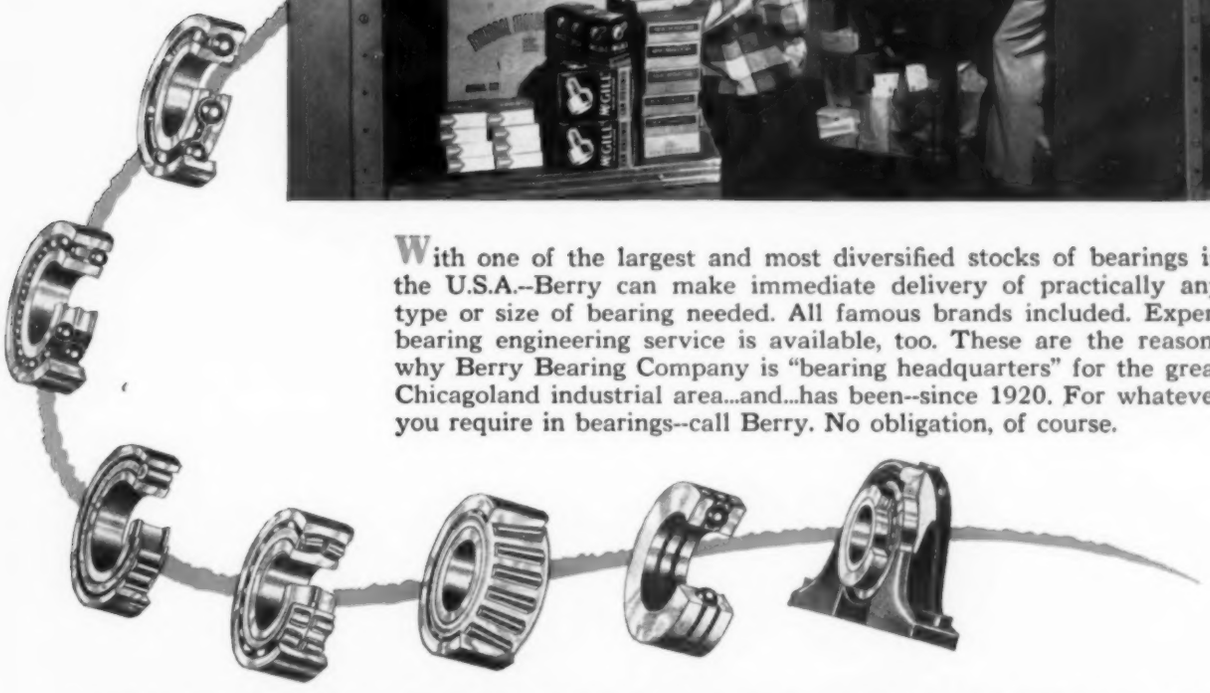
A McGraw Electric Company Division

CANONSBURG • PENNSYLVANIA

When you're in a hurry for any type--

Bearings

With one of the largest and most diversified stocks of bearings in the U.S.A.--Berry can make immediate delivery of practically any type or size of bearing needed. All famous brands included. Expert bearing engineering service is available, too. These are the reasons why Berry Bearing Company is "bearing headquarters" for the great Chicagoland industrial area...and...has been--since 1920. For whatever you require in bearings--call Berry. No obligation, of course.



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Ohio Rolls
SHAPING METAL FOR ALL INDUSTRY
THE OHIO STEEL FOUNDRY CO.
LIMA, OHIO • Plants at Lima and Springfield, Ohio

Industry News...

ROLL FIRST SLAB ON COMPLETELY REBUILT 54-IN. HOT MILL AT WEIRTON STEEL CO.

▲ The first slab of steel was rolled August 16, in the completely rebuilt 54 in. hot mill in the Strip Steel Department of Weirton Steel Co. The hot mill is a part of National Steel's multimillion dollar expansion program.

The mill, on which construction was started about nine months ago, has a rated capacity of 225,000 tons per month, or 2,700,000 tons per year. It has a delivery speed of 2,400 fpm. The mill is nearly 1,500 ft long, with a 426-ft runout table.

The hot mill consists of three slab-handling furnaces and five stands of a roughing train, replacing four furnaces and four roughing stands used in the old mill.

The roughing train will handle steel slabs 26 ft long, 48 in. wide and 7½ in. thick, with a 30,000-lb maximum weight, and reduce them to ¾-in. thickness.

The two-high No. 1, 2 and 3 roughing stands have 44-in. diameter rolls, while No. 4 stand is four-high with 35-in. work rolls and 49-in. back-up rolls. No. 5 stand is the same as No. 4.

Each of the furnaces for the mill is rated at 200 tons per hour.

The new finishing train consists of six stands of 26¼ and 49 x 54-in. mills, and its power and speed have been increased to handle the steel from the enlarged roughing mill. Three new mandrel-type coilers will replace the two existing basket-type coilers at the end of the runout table.

SHIP TRANSFORMERS FOR NEW ENGLAND MILL

▲ Two furnace transformers for New England's first specialty steel mill were shipped recently by the General Electric Co.'s Power Transformer Department at Pittsfield, Mass.

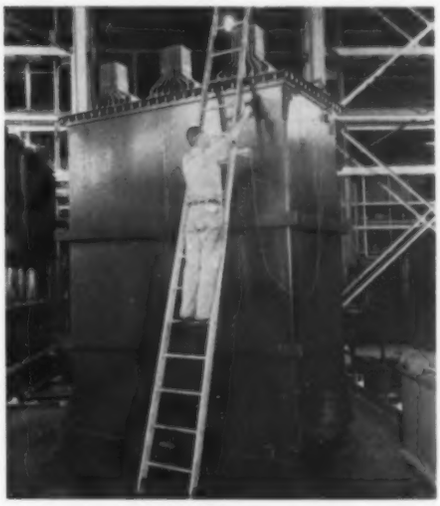
They were built for the Pittsburgh Lectromelt Furnace Corp. which is supplying two arc-melting furnaces for the Northeastern Steel Corp. at Bridgeport, Conn.

Power for the furnaces will be supplied at 13,800 volts, and the transformers will "step down" the voltage from this level to the low-voltage, high-current required to melt the steel charge in the furnaces at 6000 F. Each transformer can supply its furnace with a maximum of 29,460 amp. Almost 2000 standard 15-amp household fuses would be required to carry this amount of current.

General Electric's Pittsfield plant is also supplying three large current-limiting reactors. These will be used in conjunction with a 20,000 kva synchronous condenser made in G.E.'s Schenectady, N. Y., plant to regulate the voltage at the terminals of the transformers.

The Northeastern Steel Corp. was incorporated last December and on January 1 began operation of the Stanley Works steel plant, formerly

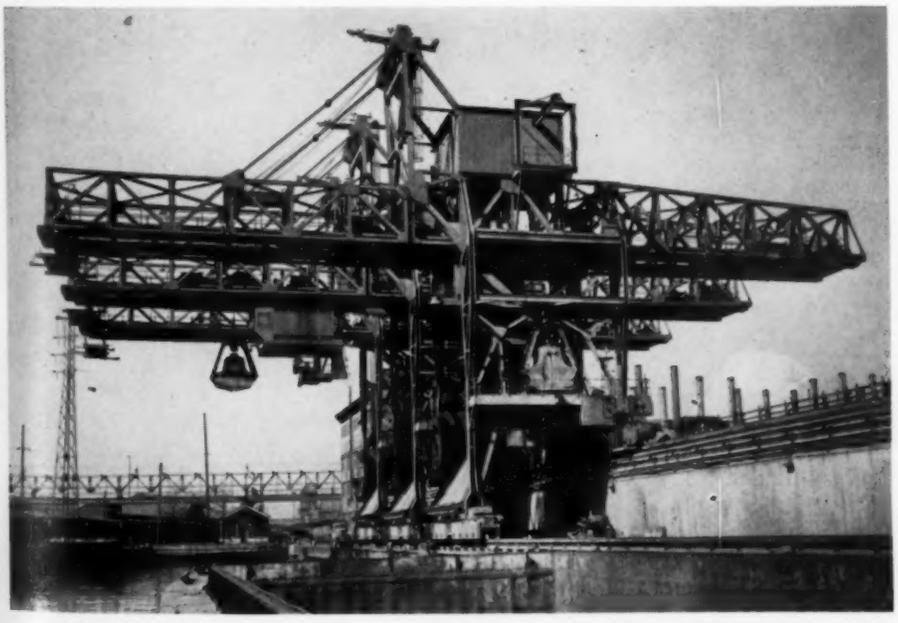
TUNE-UP!



Furnace transformer gets final check at GE plant. Thick copper taps atop unit will carry 29,460 amperes of current into arc furnaces of Northeastern Steel Corp.'s Bridgeport, Conn., plant.

ORE UNLOADERS AT US STEEL'S SOUTH WORKS

Three of seven new ore unloaders recently installed in a modernization program at United States Steel Corp.'s South Works in Chicago, Ill., are located on the South Dock. The seven machines, equipped with Dravo Corp. man-trolleys and hydraulic buffers, will handle approximately five million tons of ore and 800,000 tons of limestone received annually at South Works. The man-trolley on each unloader operates along a 165-ft runway. At the land end of the runway is a hydraulic buffer with a six-ft stroke. Two compression type buffers with two-ft strokes are mounted on the water end of the runway. Either buffer arrangement is capable of absorbing the energy of the trolley at normal operating speed.



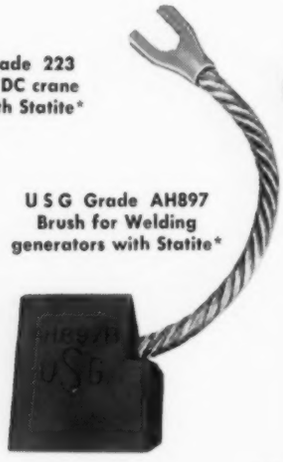
HERE'S THE USG® BRUSH THAT DOES AN OUTSTANDING JOB ON ALL YOUR MILL MOTORS

When you replace the brushes on your mill motors, you can get the best results with U S G Grade 135 Brush with Statite®. For brushes that give superb results in other applications, see below. Write for your copy of the complete U S G Brush catalog today.

A typical U S G Grade 135 Mill Motor Brush with Statite*

U S G Grade 1658 Brush for tin line collector rolls

U S G Grade 223 Brush for DC crane motors with Statite*



U S G Grade AH897 Brush for Welding generators with Statite*

U S G Grade 550 for AC Crane Motor Rings

*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

203

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

known as the American Tube and Stamping plant. The plant is now the nucleus of an expanded operation which will be New England's first specialty steelmaking facility designed to serve New England industries.

REPUBLIC TO REPLACE 150 COKE OVEN DOORS

▲ Republic Steel Corp. will install new doors on the number five coke oven battery at its Cleveland, Ohio plant to eliminate smoke leakage, M. E. Goetz, district manager, announced.

The company also will install three new exhaustors at its chemical by-product plant to exhaust gas more efficiently from the number five battery and the number one-four batteries. Both programs are in addition to the $10,000,000 which Republic already has spent at the Cleveland plant since the war to alleviate air pollution.

This latest improvement involves the replacement of 150 coke oven doors with the most modern self-sealing equipment which uses stainless steel to secure a perfect seal. This means changing doors at both ends of each oven in the 75-oven battery. The doors will be virtually smoke free.

Each door will be approximately 18 in. wide, 13 ft high and weighs about a ton.

APPOINT REPRESENTATIVE FOR SOUTHEASTERN U. S.

▲ Heyl & Patterson, Inc., has appointed George M. Meriwether, Birmingham, Ala., as its sales representative for special materials handling equipment in the states of Ala., Ga., Miss., Tenn., Fla., and Southeastern La.

COKE OVEN CONTRACT AWARDED TO WILPUTTE

▲ Wilputte Coke Oven Division, Allied Chemical & Dye Corp., has been awarded the contract for the design and construction of 52 by-product coke ovens at the Wisconsin Steel Works, South Chicago.

The new ovens, with a rated capacity of 795 tons of coke per day, or about 290,000 tons per year, may be underfired with coke oven or blast furnace gas.

Reduce

HOT STRIP RUN-OUT TABLE Maintenance

with Y&M

Ductile Cast Iron ROLLS

Resist Heat Check and Warpage
Exceptionally Good Under the Sprays

We invite your inquiries on table rolls or any other ductile cast iron castings up to 100,000 pounds.

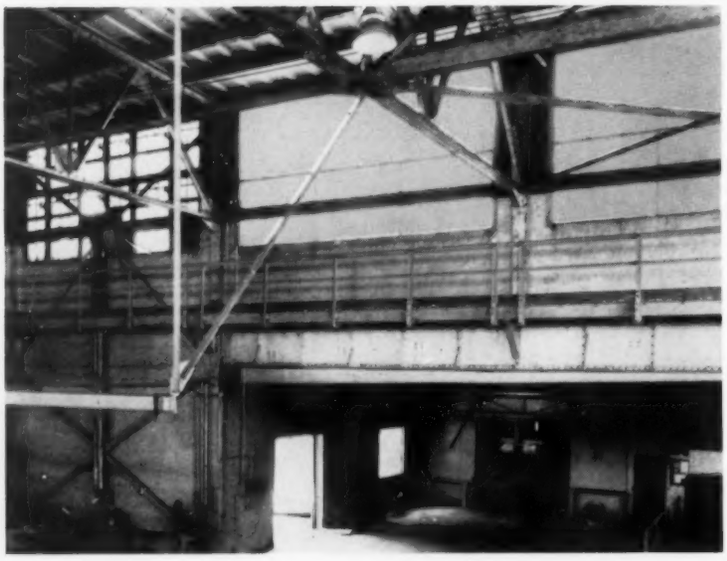
The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

12

Resolite PULLS IN the daylight at Youngstown Sheet & Tube!



TOP — A portion of Youngstown's Electrolytic Tinning Line Building, showing part of the Resolite band of daylight.

RIGHT — Note the uniformly daylighted interior of the same building.

BELOW — Better work can be done in a well-daylighted shop. A view in the Tin Mill Carpenter Shop.

Yes, ordinary industrial skylights and windows may *let* in the daylight; Resolite, the quality fiberglass panel PULLS it in. The millions of resin-encased glass fibers pick up and scatter daylight and light up the whole interior to a brightness unmatched by any other medium.

For example, in the top picture, compare the ceiling above the Resolite band and that of the conventional glazing.

Shatterproof Resolite solves replacement cost problems, too. It isn't the first cost, but the cost of upkeep labor that wrecks the maintenance budget.

Resolite is available in factory-cut flat panes and in all standard sheet corrugations.

FIRE-SNUF is the grade to specify where building codes require a "slow burning" material with a flame spread rating of 75 or less. Available at extra cost, Fire-Snuf has all the qualities of Resolite, but in addition it is self-extinguishing. It is made in all corrugations and in flat panes.

RESOLITE Corp.
Box 156,
Zelienople, Pa.

Warehouse and sales office, Chicago
Distributors in principal cities, U. S. and Canada.

BUILDING OF AMMONIA PLANT SET FOR FALL

▲ Heavy construction is expected to start on the anhydrous ammonia plant this fall at the Geneva Works of U. S. Steel's Columbia-Geneva Steel Division, it is announced by the Blaw-Knox Co., Chemical Plants Division, designers and builders of the plant.

Engineering work is in progress for the plant at Geneva Works and the big task of procuring materials is under way. Ground has been cleared, foundation tests for footings have been completed, and the site is being prepared for the start of construction.

The project will include:

1. A 200-tons-per-day anhydrous ammonia plant, using the Blaw-Knox-Linde low temperature separation process to recover hydrogen from the coke oven gas and to extract high purity nitrogen from the air; and using the Blaw-Knox-Montecatini process for ammonia synthesis.

2. A nitric acid plant based on the oxidation of ammonia.

3. A fertilizer-grade ammonium nitrate plant, using the prilling process, producing both solid and solution forms of the product.

4. The necessary complement of auxiliaries, including an administration building for offices and laboratory; a general service building containing a change house, machine shop, and parts storage; compressor building; utilities; warehouses; and extensive handling, bagging, storage, and shipping facilities.

TO EXPAND FACILITIES FOR PRODUCTION OF FOIL

▲ A $19-million expansion of aluminum foil production facilities, which will enable the company to produce an additional 32-million pounds of foil annually was announced by Aluminum Co. of America for its Davenport, Iowa, and Alcoa, Tenn., plants. Construction at the two sites will begin immediately. Major portion of the expansion is scheduled for the Davenport plant, where $15, 200,000 is earmarked for eight large foil rolling mills, as well as for annealing furnaces, shears and auxiliary equipment.

A $3,800,000 Tenn. expansion will add three foil rolling mills, together with annealing and shearing sup-

for higher performance it's

OHIO MAGNETS

Size for size, Ohio Magnets lift larger loads over longer periods because they *operate cooler*. So for extra magnet lifting power, extra magnet value—always specify Ohio Magnets and Ohio Magnet Controllers. There's a type and size for every lifting job. Send for free copy of Bulletin 112, or consult the Yellow Pages for Ohio offices in principal cities.

AA-1477

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5400 DUNHAM ROAD • MAPLE HEIGHTS • CLEVELAND, OHIO

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CHESTER BLAND
President

Ohio Also Makes Separation Magnets • Nail Making Machines • Fractional Horsepower, Shell and Torque Motors

porting equipment. The additional facilities are expected to begin operation in about 12 months. Neither the Davenport or Alcoa facilities will be ready for operation until after completion of new smelting facilities, which are now being constructed as additions to the company's Rockdale and Point Comfort, Tex., aluminum-producing plants.

C. S. GORDON CO. NAMED WESTINGHOUSE AGENT

▲ The Claud S. Gordon Co. of Chicago, Ill. has been appointed an exclusive distributor of Westinghouse standard industrial furnaces and related equipment.

As founder and president of his company, Mr. C. S. Gordon has been engaged in the industrial furnace and control business since 1913. Prior to the appointment as exclusive Westinghouse distributor, the company had sold the furnaces of ten different manufacturers as well as their own line of Exactline instruments and control devices.

The Chicago firm will have exclusive rights for the sales in eight midwestern states of Westinghouse box type furnaces, cylindrical pit and rotary hearth furnaces as well as melting pots and both Endogas and Exogas atmosphere generators.

J & L PURCHASES SITE FOR NEW BAR MILL

▲ Purchase of a 31-acre industrial site at Willimantic, Conn., has been announced by Jones & Laughlin Steel Corp

C. L. Austin, J&L President, said the site will be used initially for construction of a plant to produce cold finished steel bars.

OPEN REFRACTORIES PLANT IN LESLIE, MD.

▲ The Harbison-Walker Refractories Co. has opened a new plant at Leslie, Md. to produce silica refractories, according to an announcement by Earl A. Garber, president.

The plant is a 100,000-sq ft standardized steel structure, modified structurally to accommodate several elevated grinding and screening machines and one of the longest tunnel kilns in the world.

The new manufacturing unit is Harbison-Walker's 33rd in this country and Canada. It is the latest major addition in a $35,000,000 expansion program launched in 1951.

The factory was designed so as to permit future expansion in either direction. It consists of several connected rigid-frame, 60-ft clear-span structures of varying lengths and heights, totaling 92,400 sq ft, plus a connected 8,400-sq ft flat roof building.

The longest section runs 880 ft and houses, among other facilities, a tunnel kiln that is 504 ft long and accommodates 61 loaded cars. A system of exhaust, air and cooling fans is located above the kiln. The tallest part, where the grinding machines are located, is 55 ft high, while the others vary in height from 16 to 30 ft.

BEGIN CONSTRUCTION ON ROYAL OAK PLANT

▲ Square D Co. will begin construction immediately on a new plant to be located in Royal Oak, Mich., and has begun production at two recently-completed units in Cedar Rapids, Ia., and Secaucus, N. J.

With the Royal Oak plant scheduled for substantial completion this year, the combined new facilities will represent one-quarter million square feet of manufacturing floor space added in 1955.

REES MACHINERY CO. APPOINTED SALES AGENT

▲ Wiedemann Machine Co. appointed Rees Machinery Co., Inc., Pittsburgh, Pa. as their exclusive sales representative in Western Pa. Southeastern Ohio and all of W. Va.

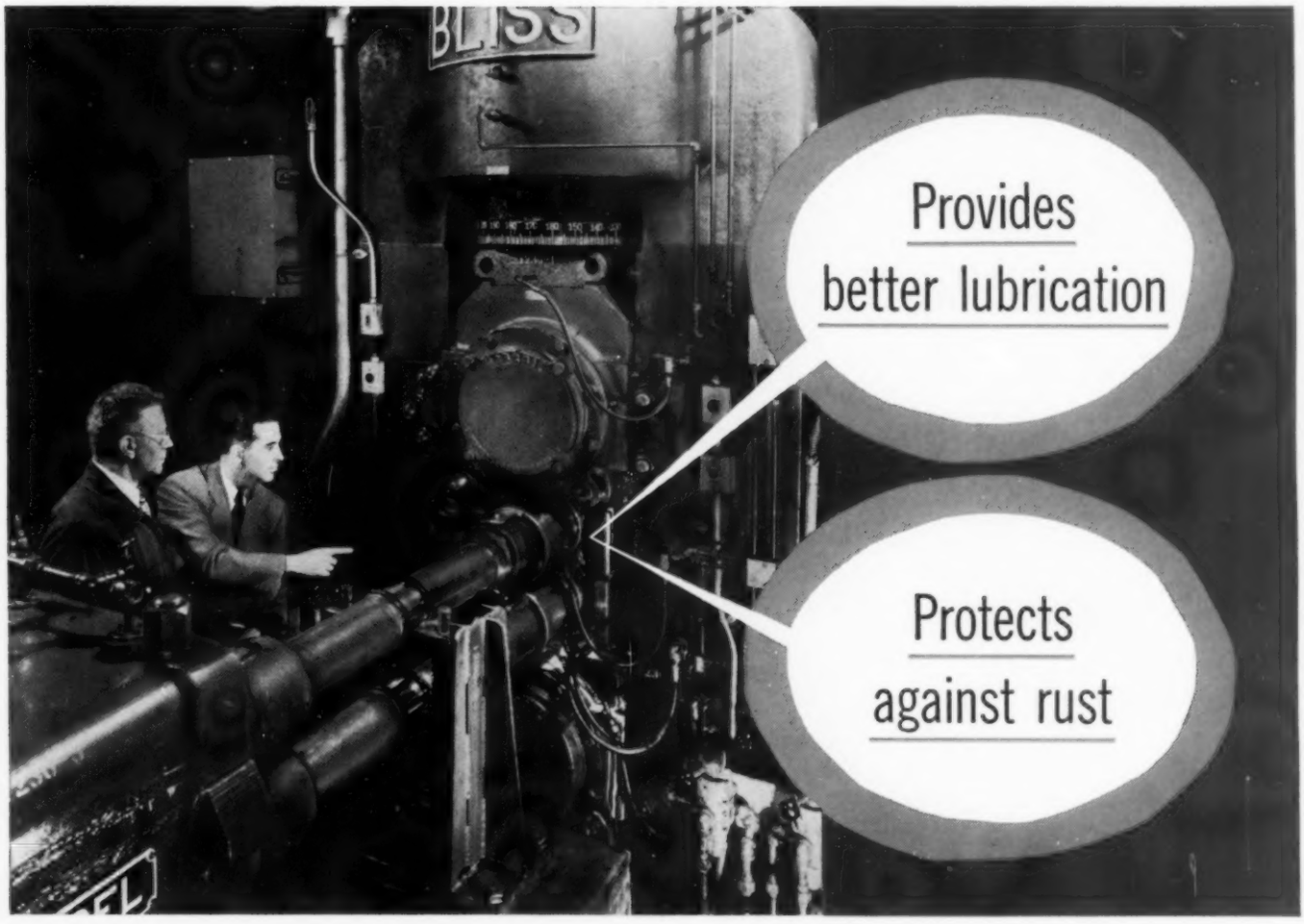
BAR MILL CONTRACT AWARDED TO BIRDSBORO

▲ Award of a $1,700,000 contract for the manufacture of a 15 stand bar mill was announced by the Birdsboro Steel Foundry and Machine Co. The new mill has been ordered by Rotary Electric Steel Co. as a major part of its expansion program.

Cost of the complete installation, including motors with a total name

For double barreled protection of anti-friction roll neck bearings . . .

GULF XXX LUBRICANT



YOUR roll neck bearings not only get outstanding protection against wear with Gulf XXX Lubricant — they also get effective protection against rust. This double-barreled protection adds up to long life and low maintenance costs.

Gulf XXX Lubricant has exceptional extreme pressure characteristics—rollers and races are fully protected against shock loads or overloads.

Gulf XXX does not wash out of bearings when subjected to large quantities of water. And its excellent pumpability makes it ideal for centralized lubricating systems.

Have a Gulf Sales Engineer demonstrate these advantages of Gulf XXX Lubricant in your plant.

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THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

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ELECTRIC MOTORS
...the choice of leaders in industry

New NEMA Frames
Standard and Explosion-proof

Type EP
215 Frame

Wagner Totally-Enclosed Fan-Cooled Motors

cut maintenance time and costs

Check the features of the new *Wagner Type EP Totally Enclosed Motor*. They spell the difference between needless expenditures in maintenance time and costs . . . and a definite savings in motor upkeep and repairs. You'll find that for general industrial use where dust, dirt, filings, abrasives, steel chips or moisture are present, the Wagner Type EP Motor gives steady, troublefree performance and longer service life.

Wagner Type JP Explosion-Proof Motor . . . has the same quality construction as the Type EP – plus added features which make it completely safe to operate where explosive dust, gases or vapors are present.

Both Type EP and JP Wagner motors are available in ratings up to 250 horsepower. For complete information, just call the nearest of our 32 branch offices, or write for Bulletin MU-203.

Wagner Electric Corporation
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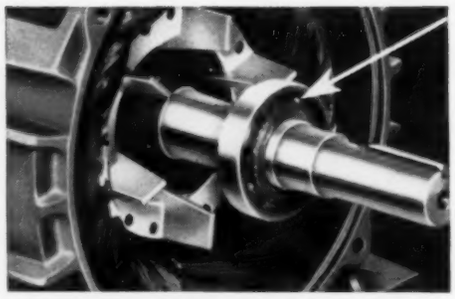
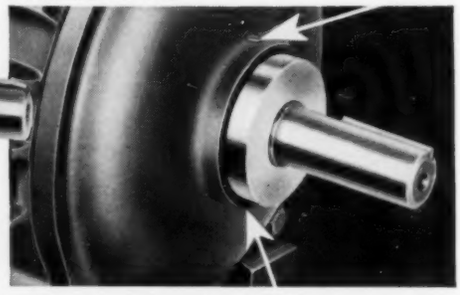
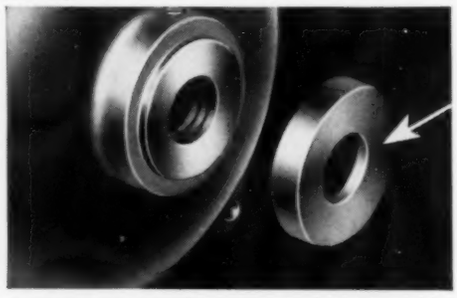


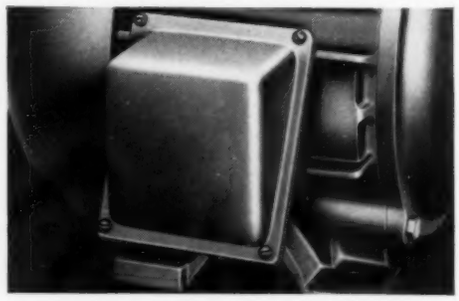
1 HEAVY-DUTY BALL BEARINGS—Highest quality bearings of more than ample capacity provide long, troublefree service.



2 BEARINGS CAN BE RE-LUBRICATED—Wagner motors can be re-lubricated when necessary to prolong bearing life.



3 BEARINGS STAY CLEAN—Both ends of these motors are equipped with running shaft seals, a machined collar mounted on the motor shaft.



4 EASY TO CONNECT—Large diagonally-split conduit box provides ample room for making connections. Leads are permanently identified.

5 NO GREASE LOSS—Bearing housings have effective seals to prevent escape of grease.

6 RIBBED FRAME—Ribs on the corrosion-resistant cast iron frames add mechanical strength and increase the surface area for more efficient cooling.

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ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS–AIR AND HYDRAULIC

plate horsepower of 3,800, will total $4,500,000, according to J. A. Shimmin, Rotary Electric's vice president of operations.

Work on the new mill, scheduled to be in operation by the second quarter of 1956, is already under way.

DE SHAZO AND THOMAS NAMED SALES AGENT

▲ Appointment of DeShazo and Thomas, Birmingham, Ala., as its franchised representative was announced by the Automatic Transportation Co. The firm will cover Ala. and the northern tier of Fla. counties.

The firm has sales and service facilities at 107 Broadway, Birmingham, where it will carry a stock of parts for equipment manufactured by Automatic.

TO DESIGN EQUIPMENT FOR ENGLISH PRODUCER

▲ Stanat Manufacturing Co., Inc. announced that final negotiations had been made with a British manufacturer to build their rolling mill equipment in England for sale to the European and Commonwealth markets. Albert Mann's Engineering Co., Ltd., Essex, England will produce the machinery from the American firm's designs.

Also included in this arrangement are rotary gang slitters, roller levelers, and wire drawing and flattening machines, which will bear the name, Stanat-Mann.

REYNOLDS PLANS GIANT EXPANSION PROGRAM

▲ Reynolds Metals Co. plans to increase its primary aluminum producing capacity to 1.1 billion lb as a result of the company's latest expansion program, the largest and most comprehensive in its history.

The bulk of the expenditures for new facilities, about $200,000,000 out of a total of $230,000,000, will be devoted to the 270 million lb expansion of primary producing and related facilities, including new bauxite mines in Haiti and Jamaica, and a giant coal-burning power plant.

The remaining $30,000,000 to be spent under the program will be used

USS

FAIRLESS WORKS uses DIAMOND INDUSTRIAL TV to Improve Operation and Cut Costs

Arrow points to Diamond ITV camera (in protective housing) used to watch slab positioning.

Operator at pulpit SEES on the Diamond ITV screens when slabs are in correct position for charging two end furnaces.

Four **slab reheating furnaces are charged by** ***one*** **operator using Diamond ITV at Fairless Works of the U. S. Steel Corp. Slabs are aligned properly eliminating danger of serious damage to furnaces. Operating costs are reduced.**

You, too, probably can use Diamond ITV to substantial advantage. For case histories and suggestions, get in touch with your Graybar Distributor or use the coupon below.

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HERE'S MOLDIT—the most successful line of hydraulic setting castable refractory materials for the greatest range of industrial heating applications.

WITH MOLDIT—mixed as ordinary concrete—you pour, cast or gun your own refractories in any size and shape, fast. No high-cost inventory of special shapes to maintain.

MOLDIT OUTLASTS THE REST. Air-sets, without prefiring, to full refractory hardness. More resistant to thermal shock and abrasion.

PLANTS REPORT SAVINGS up to 90% in repair and maintenance costs when Moldit Castables replace other refractories.

Bottoms and piers of car for large steel annealing furnaces, cast of Moldit Pier Cement, outlast fire brick about four to one.

Moldit Chrome being poured and troweled over the bottom of a large steel plate mill furnace.

FOR EVERY REQUIREMENT

Send for catalog on 10 different Moldit Refractory and Insulating Refractory Castables. Also get the story on R&I Super #3000, the truly "wonder" refractory bonding mortar.

Moldit Castable Refractories

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for fabricating facilities, principally for the modernization and enlargement of present plants.

The principal feature of the company's expansion program is a proposed new 200,000,000 lb primary production plant in the Ohio River Valley, to cost $168,500,000 including related bauxite, power and alumina facilities.

HYDROPRESS TO BUILD TUBE TESTING MACHINE

▲ Hydropress, Inc. has received an order from Mannesmann Tube Corp., Ltd., Sault Sainte Marie, Ontario, Canada, for a tube testing machine having maximum test pressure of 13,000 psi, which is part of the equipment to be used in their newly built tube plant in Canada.

This order is in addition to the one received a short time ago for the tube testing machine for shipment to the Mannesmann plant in Germany.

NEWPORT TO REACTIVATE BLOOMING AND BAR MILL

▲ Newport Steel Corp. is preparing to reactivate the blooming and bar mill located in its Wilder, Ky., plant section.

The additional facility, now undergoing extensive reconditioning, is expected to be ready for operation before October 1, and will be devoted to production of sheet bar and plates.

With reactivation of the blooming and bar mill, which has been closed since early 1954, all of Newport's plant facilities will be in production.

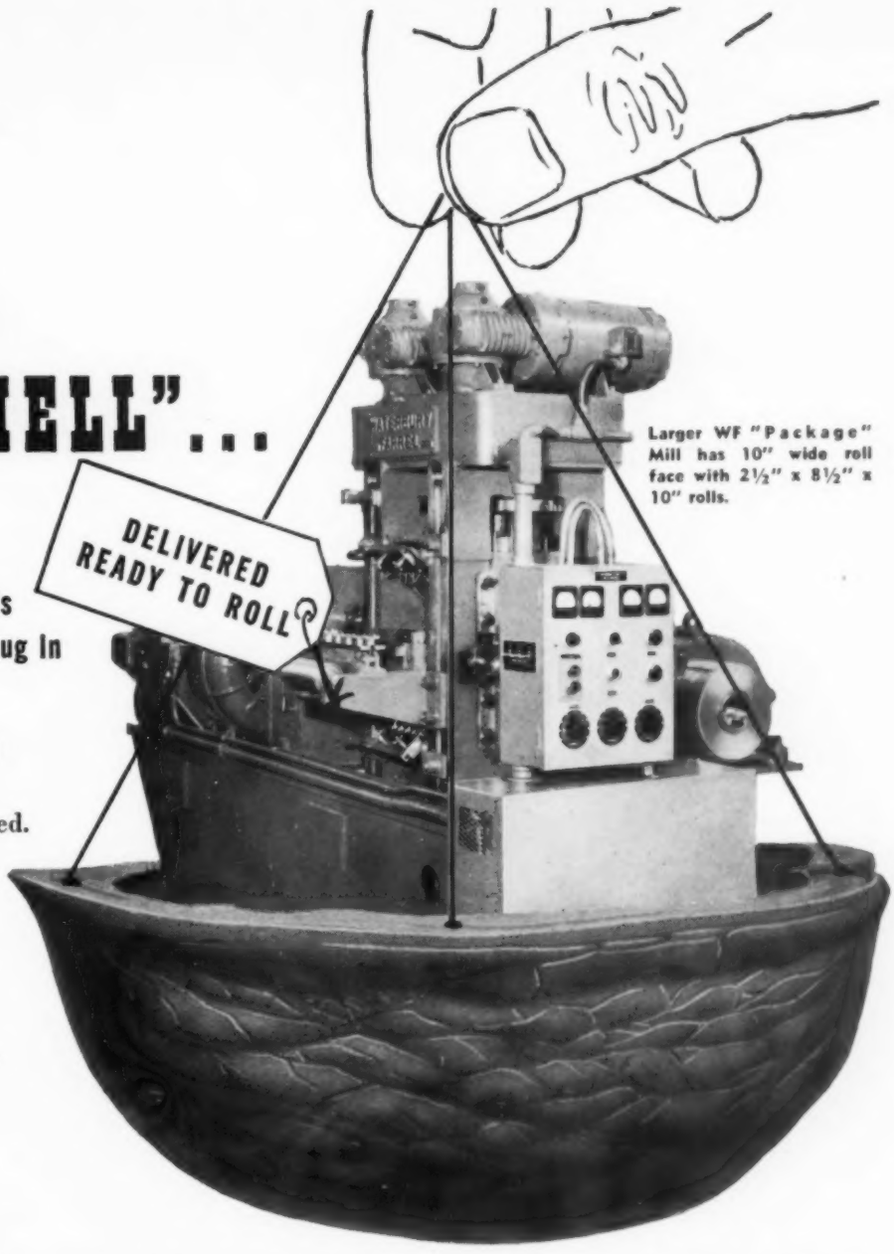
APPOINTS SALEM-BROSIUS EXCLUSIVE SALES AGENT

▲ Salem-Brosius, Inc. was appointed exclusive agent for the sale and licensing of a new, ultra-high temperature furnace and the process of Metals Chlorides Corp. of Middleport, N. Y.

The new furnace operates at temperatures in excess of 4,000 F, and is designed for continuous tonnage halogenation of oxides, ores and carbides at temperatures near to, or above, the vapor stage temperature of most metals and metallic compounds.

Waterbury Farrel's
New, ONE-PIECE

STRIP MILL "IN-A-NUTSHELL"...

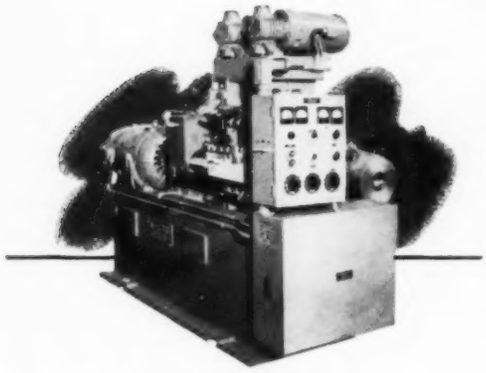


Larger WF "Package" Mill has 10" wide roll face with 2½" x 8½" x 10" rolls.

WF's 4-High "Package" Rolling Mills Are Compact, Low Cost, Ready To Plug In

You can start precision-rolling ferrous or non-ferrous strip as soon as you plug in the electrical connection.

This mill is completely self-contained. Drive, gear case, controls, lubrication system, winder and winder drive are assembled with the mill, itself, into a single, compact unit. When necessary, it can easily be moved in one piece to a new location.



Smaller WF "Package" Mill has 6" wide roll face with 1⅝" x 6½" x 6" rolls.

Some Construction Features: Mill frame of unit welded plate steel gives maximum strength and rigidity . . . assures greater accuracy and lasting alignment . . . alloy steel work rolls mounted in needle bearings . . . alloy steel back-up rolls drilled for water cooling, mounted in double row Timken bearings with tapered sleeve . . . independent power screwdowns . . . long and short roll necks and staggered couplings permit heavier construction for maximum torque capacities . . . lucite cover on welded steel gear case facilitates inspection . . . variable speed tension control drive, using AC power, cuts control cost and permits compact panel.

Contact Waterbury Farrel for complete details. No obligation.

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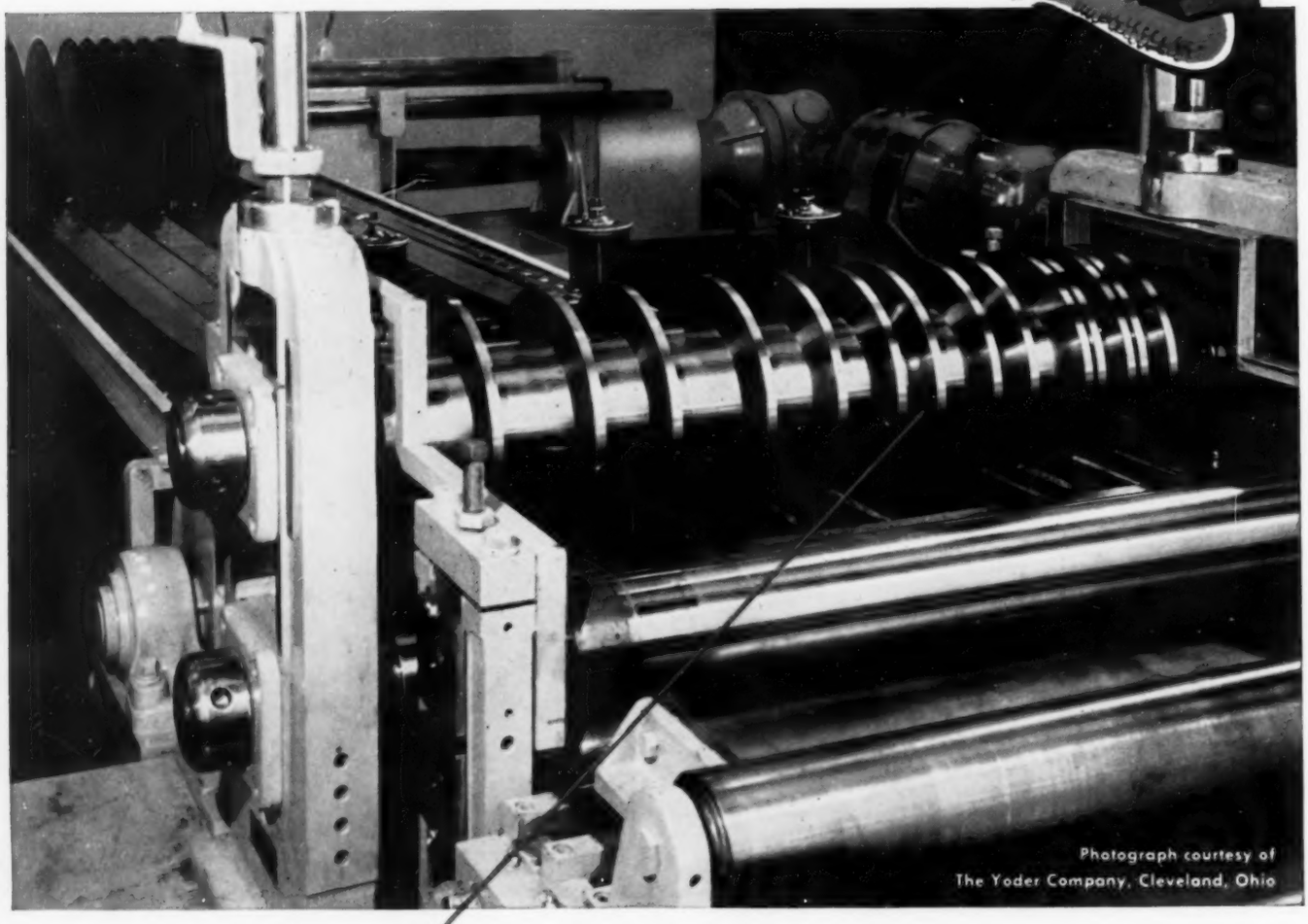
WF-17A

it's OK...let'er go!



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The Yoder Company, Cleveland, Ohio

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. . . because OK Slitter Knives run hour after hour without re-grinding, giving you top machine productivity at all times. Here's why: exact metallurgical specifications for our steel—an exclusive heat treating process to give uniform hardness and temper—special grinding and finishing to tolerances of ± .00025 or finer.

For free Bulletin, "SLITTING—A Basic Guide For The New Operator" Write Dept. 22-Z.

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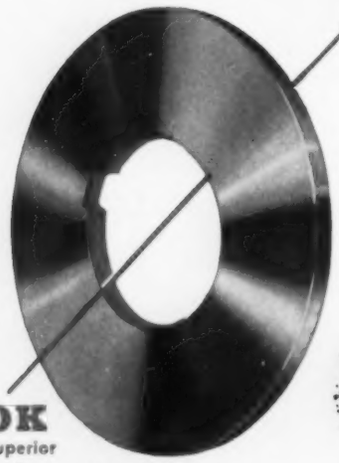

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HARDENED WAYS, GIBS, RACES • SCRAP CHOPPERS • HARDENED SPACERS

REM-CRU PURCHASES PROPERTY FROM CRUCIBLE

▲ Rem-Cru Titanium, Inc., announced the purchase of a group of five buildings and ten acres of land from the Crucible Steel Co. of America in Midland, Pa., as another step forward in the company's expansion program for tonnage production of titanium mill products.

C. I. Bradford, president and general manager of Rem-Cru, in making the announcement stated: "The purchase of this property will allow us to move toward our goal of constructing completely integrated facilities for producing titanium mill products."

The property acquired includes five buildings, which were built since 1942, with floor space in excess of 237,000 sq ft. These buildings are equipped with modern materials handling facilities, pickling lines and other metal processing equipment which easily can be converted for the needs of titanium production.

Meetings

▲ The Industrial Heating Equipment Association is sponsoring a two-day symposium, in connection with the American Metals Congress in Philadelphia, Pa.

Seven executives from the Association's member companies will present industry-wide reports on recent developments in vacuum melting, strip annealing, combustion systems, mechanized molten bath and batch type furnaces, mechanized continuous furnaces, and induction heating.

The meetings will be held at 2:00 p.m., October 18 and 19, in the main ballroom of Convention Hall, Philadelphia, Pa. Men from the steel industry are invited.

▲ The American Society of Mechanical Engineers will celebrate their diamond jubilee in Chicago the week of November 13. At the same time, the National Exposition of Power and Mechanical Engineering, sponsored by ASME, will be held at the Chicago Coliseum.

ASME will send complimentary tickets to the exposition and a program of their meeting to AISE members who write ASME, 29 West 39th St., New York 18, N. Y. They will charge individuals who are not members of ASME a registration fee of $10.00 for attendance at the meeting.

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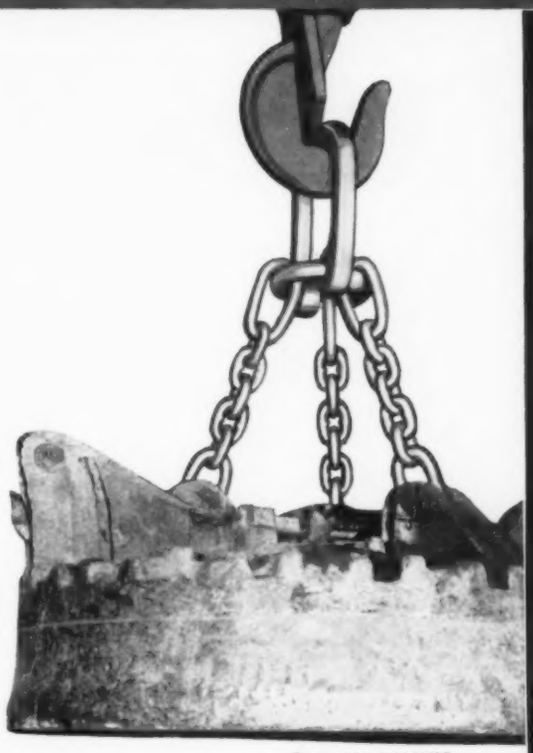
ALLOY STEEL

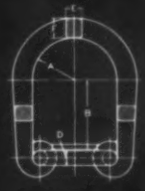
DOWNTOWN TYPE

MAGNET CHAIN

lasts 5 to 15 times longer

than conventional three-leg types!





New Lifting Bail Design

provides larger opening for crane hook. Heavy, squared-type Alloy Steel construction assures longer life.

Locating Plate

takes larger joiner links with squared top sections—keeps chain legs at 120° centers to reduce wear due to friction, twisting and gouging.

Patent No. 2626175

Designed to eliminate wear due to twisting—reduces the lifting angle and therefore increases the strength and life of chain. Made with Taylor Made Alloy Steel Chain, it has twice the strength of wrought iron assemblies. It's tougher too! Heat-treated—it has great resistance to shock lifts, grain-growth and work-hardness at low temperatures—never requires annealing. Lasts five to fifteen times longer!

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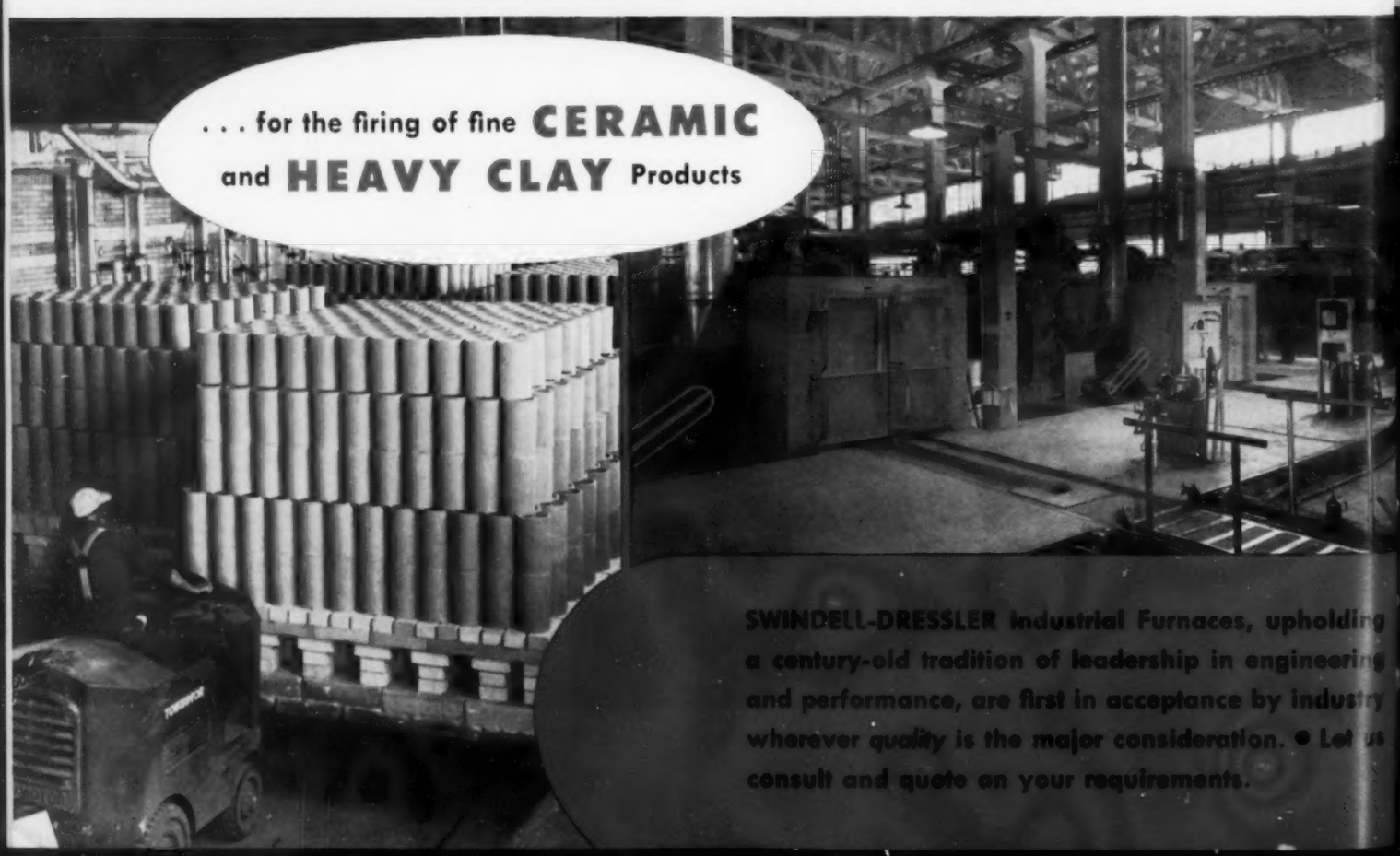

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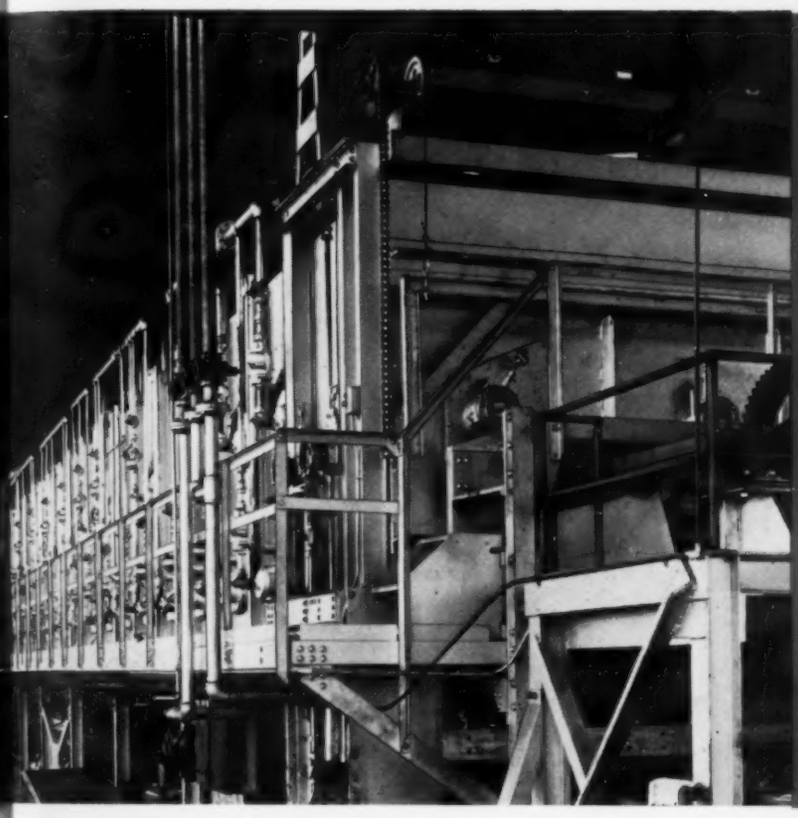
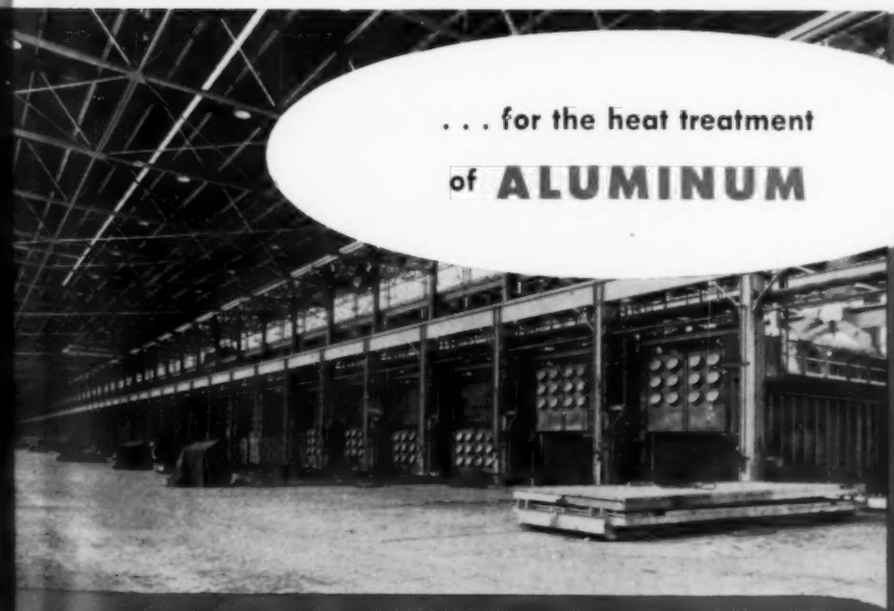
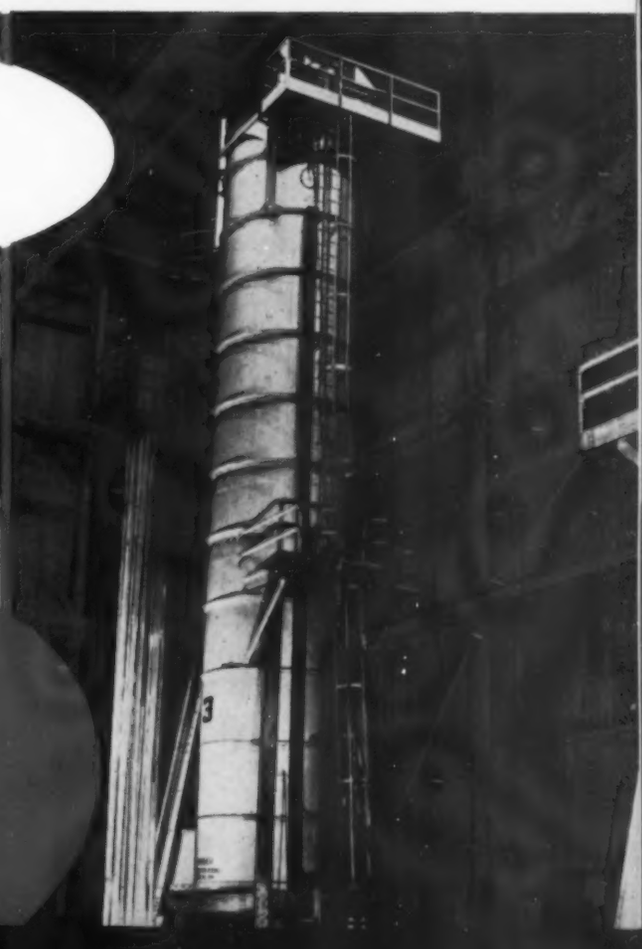


. . . for the heat treatment

of **ALUMINUM**





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From one source . . . any instrumentation you need

When it comes to measurement and control, every industrial process is different. Each demands its own combination of accuracy, economy, instrument ranges, and all the numerous other characteristics that are peculiar to the individual application.

No single instrument and its accessories could possibly fit every process. So Honeywell makes a broad variety of measuring and controlling equipment that spreads across a tremendous range of applications.

The advantages are two-fold. First, you can get all the instrumentation your process requires from a single source, so there is undivided responsibility for the complete installation. And second, you are assured that the equipment selected for your process is recommended without bias . . . neither over-sells nor under-equips . . . needs no stretching, squeezing or compromising to fit it to its assignment.

This versatile family includes *ElectroniK* indicators, recorders and controllers in circular and strip chart models, applicable to temperature, pressure, pH, power and dozens of other variables; square root flow meters for control applications; evenly graduated flow meters for cost accounting; thermometers, pressure gauges and liquid level meters; *Pyr-O-Vane* millivoltmeter controllers. Especially useful for graphic panels are the *Tel-O-Set* miniature indicators, recorders and controllers. Electric and pneumatic control systems range from the simplest to the most complex, including automatic program controls and complete systems developed for particular processes.

Working with these instruments is a full choice of primary elements . . . thermocouples, *Radiamatic* radiation elements, pressure-type and electrical resistance thermal systems, flow meter bodies, pH cells and many others. For final control elements, you can choose from a wide range of electric motorized and diaphragm operated valves. To complete the picture, there are more than 7000 non-indicating devices for controlling temperature, pressure, vacuum, liquid level and humidity . . . an unmatched variety of instrumentation made by the world's largest manufacturer of control equipment.

Brown control helps Alan Wood use by-product

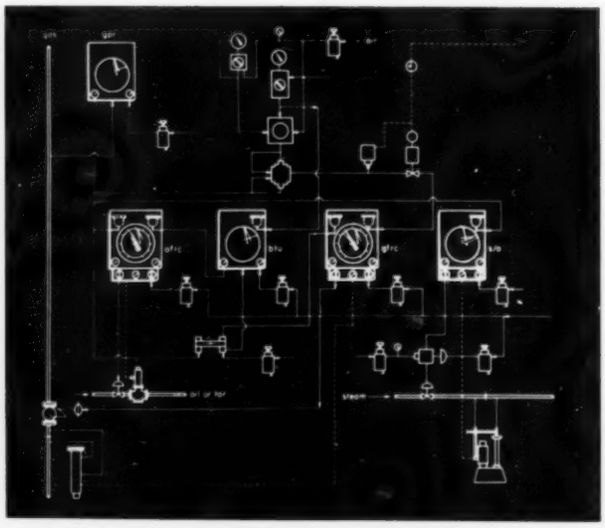
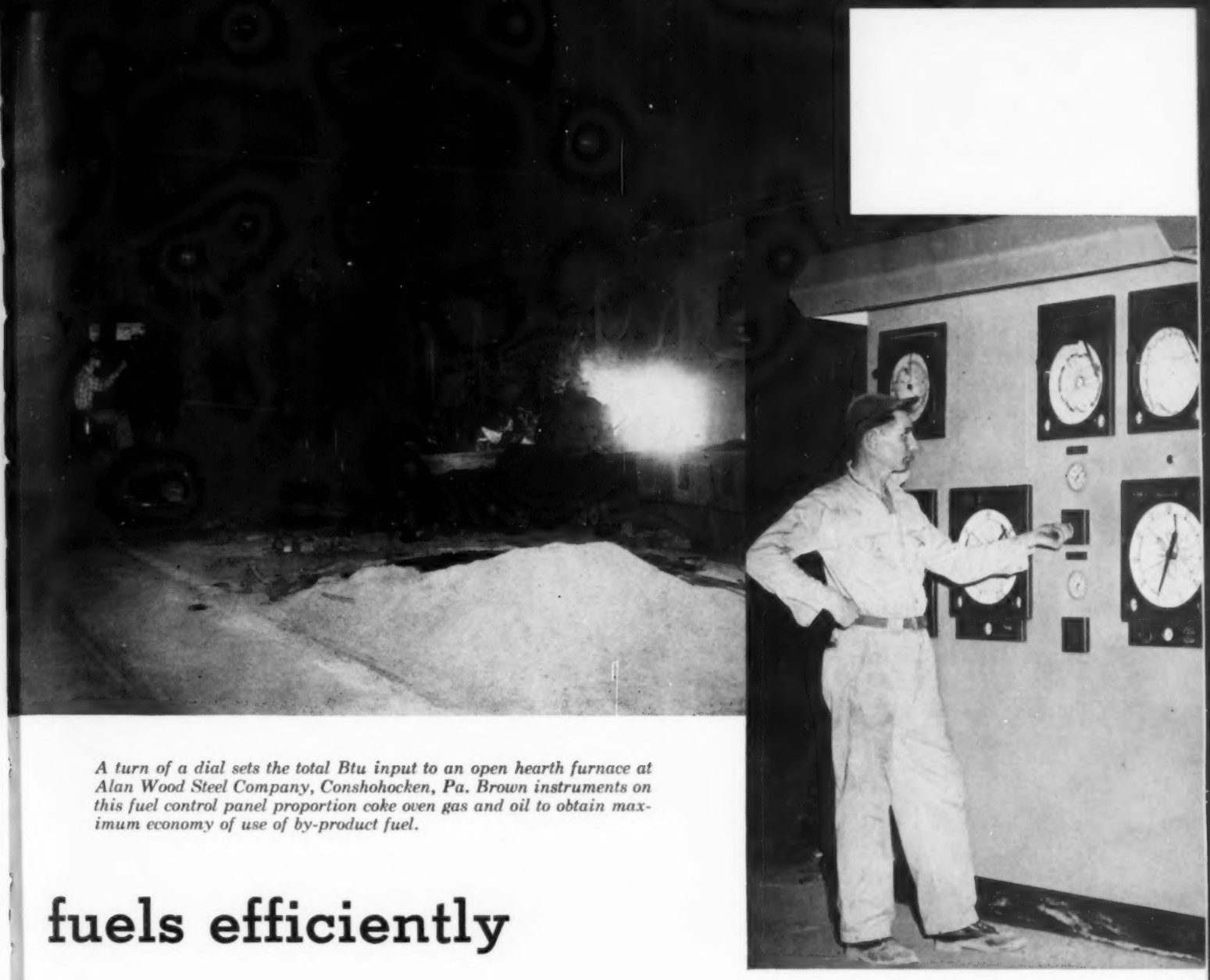


Diagram shows elements of the Brown fuel control system for mixed-fuel firing of an open hearth furnace. Instruments include gas pressure recorder, oil flow controller, gas flow controller, total Btu controller and steam flow controller



A turn of a dial sets the total Btu input to an open hearth furnace at Alan Wood Steel Company, Conshohocken, Pa. Brown instruments on this fuel control panel proportion coke oven gas and oil to obtain maximum economy of use of by-product fuel.

fuels efficiently

ECONOMICAL utilization of by-product fuels can prove the means of substantial cost reductions in steel mill operations. Alan Wood Steel Company accomplishes this objective with the help of an integrated Brown control system applied to its open-hearth furnaces.

The control system mixes coke oven gas with the base fuel, which is oil or tar. It automatically uses as much of the coke oven gas as is available . . . then proportions the base fuel to provide the required total Btu input. In addition, it regulates combustion air to maintain the desired fuel-air ratio for efficient combustion.

Operation is fully automatic. The operator sets the Btu input he wants, and the instruments decide whether coke oven gas is available . . . proportion it to oil feed . . . and adjust air flow in accordance. The operator can take over by means of remote manual control units, when necessary.

On the instruments, fuel engineers get a complete record of gas and oil flow, Btu input and gas pressure . . . from which detailed analysis of each heat can be made. The charts also help to show operators related trends in values important to fuel economy in the particular furnace.

Brown fuel-air ratio control systems, custom-designed for your specific requirements, can help you maintain high efficiency and economical operation of any furnace. For a discussion of your application, call your local Honeywell sales engineer . . . he's as near as your phone.

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● **REFERENCE DATA:** Write for Data Sheet No. 4.3-4a, "Fuel-Air Ratio Control Systems for Metallurgical Furnaces.

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RAMMING MIX BOOKLET

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THIS new free booklet is the most valuable handbook on steel furnace bottom ramming procedures ever offered.

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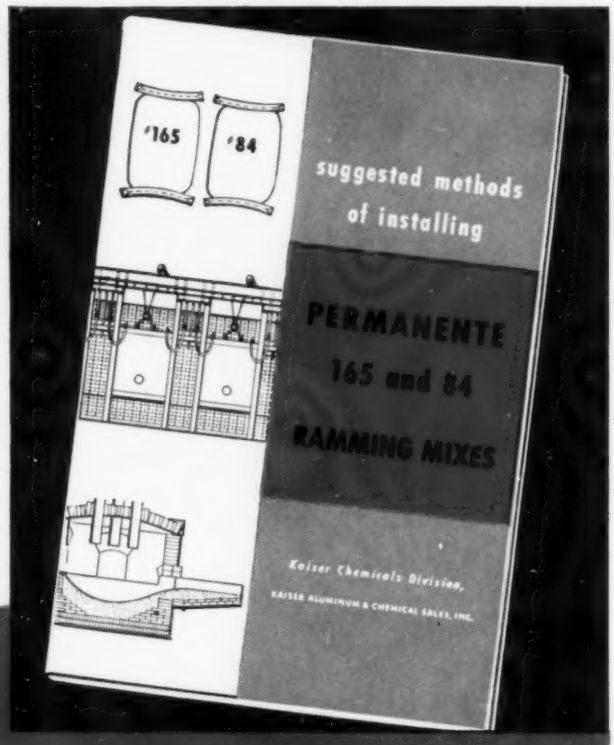
Many of the suggestions and recommendations contained in this 36-page booklet have come from our customers, who cooperated in joint studies in their open hearths and electric steel furnaces.

All of the recommendations are designed to help you obtain substantial savings and establish new performance records through the proper use of Permanente #165 Ramming Material and Permanente #84 Ramming and Patching Material.



What the booklet contains:

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2. Purity and amount of water to use.
3. Continuous ramming.
4. Ramming the flat.
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9. Open hearth heat-up schedules.
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ALWAYS USE ALCOA ALUMINUM ACCESSORIES WITH ALUMINUM CONDUCTORS

Blaw-Knox keeps crane cab temperatures down when furnace heat goes up

When the lid is off this 2400 F furnace for charging, its heat rises to surround the crane cab—making work practically impossible. To avoid the major work problem that such excessive heat creates for many foundries, the Rolls Division foundry of Blaw-Knox installed a Dravo Crane Cab Conditioner.

Like Blaw-Knox, foundry operators everywhere find that Dravo Conditioners are the answer to their overhead crane "hot spot" dust, dirt or fume problems. With Dravo Conditioners, cab temperatures are held at a 75-85 F maximum, while ambients may soar as high as 180 F. In addition to holding cab temperatures to a comfortable, efficient work level, Dravo Conditioners also remove dust, dirt and fumes from air entering the cab and provide year-round ventilation.

DRAVO
CORPORATION
PITTSBURGH, PENNA.
Sales Representatives In Principal Cities

No matter where they're put to work, Dravo Industrial Air Conditioners pay big dividends by providing effective protection from excessive heat, dust, dirt and fumes. We'd like to tell you more about how these efficient, rugged, easy-to-install units can help you. Why not mail the coupon now or phone the nearest Dravo sales office!

Dravo Corporation, Air Conditioning Department
Fifth and Liberty Avenues, Pittsburgh 22, Penna.

DRAVO

☐ Please send Bulletin 1301A "Crane Cab Conditioners."
☐ Please have a representative call at no obligation to me.

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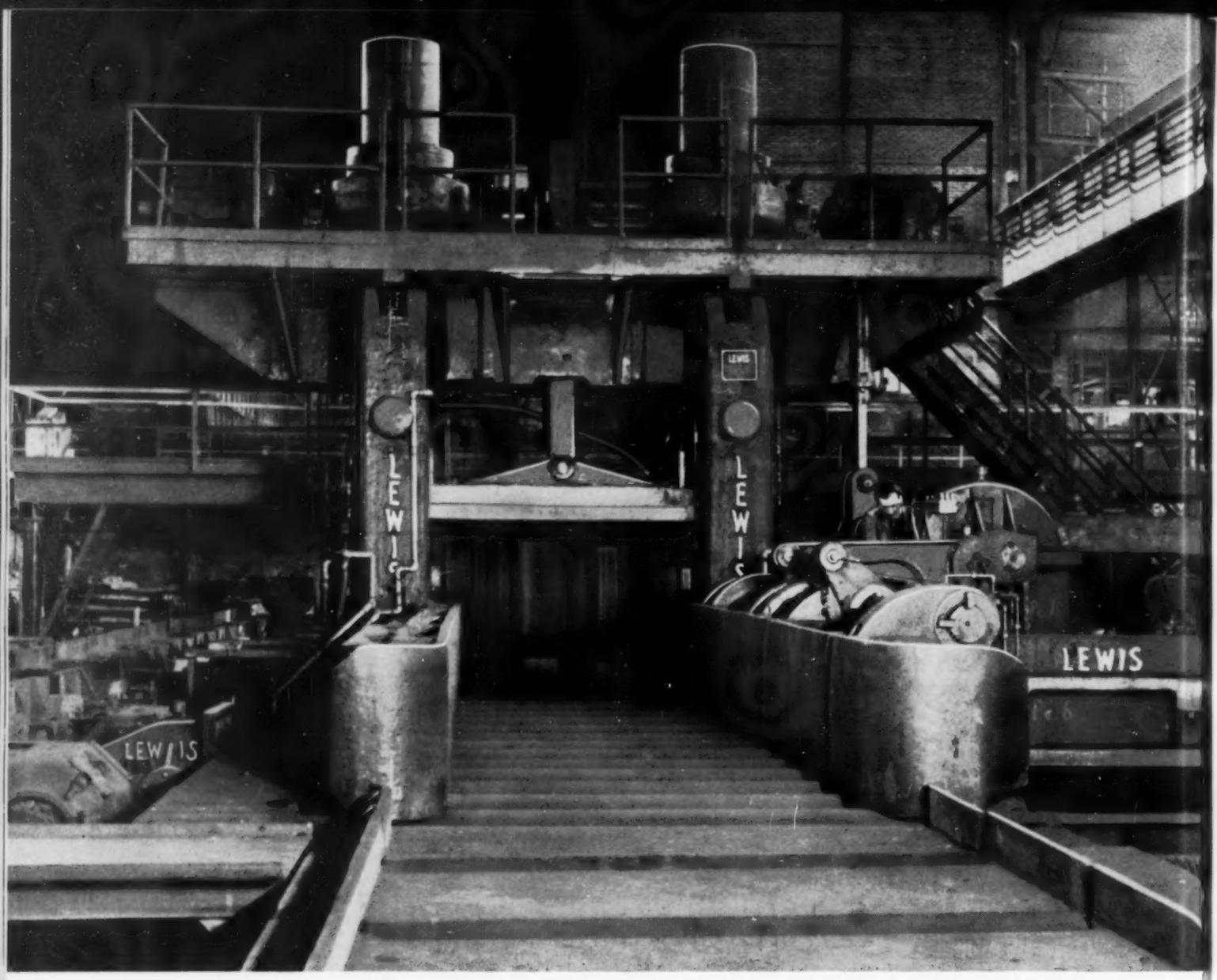


. . . roughing mill used in production of all standard structural shapes

This 36″ x 82″ Lewis two-high Hot Reversing Roughing Mill was designed and built for use in the production of standard structural shapes.

Although the rolls used in the mill are 36″ pitch diameter and 82″ body length, the large diameter collars needed for beam sections required windows 54″ wide—which is equivalent to those in the usual 44″ to 46″ mill. The cross sections of the sturdy housing posts are 425 square inches.

The mill is equipped with front and back mill tables, which have rack type side guard manipulators 28½″ high for handling the heavy beam blanks that come from a primary blooming mill. Six lifting fingers are provided on the one side guard on each side of the mill.

Driven by a 6300 hp, dc motor, this Lewis Mill can be reversed from 69 rpm forward to 69 rpm in the opposite direction in about two seconds.

Whether you may need a roughing mill of this type or some other kind of mill, our experienced engineers and modern manufacturing facilities are always available to design and build sturdy mill equipment to meet your specific requirements.

BLAW-KNOX COMPANY

LEWIS MACHINERY DIVISION PITTSBURGH 30, PENNSYLVANIA

BLAW-KNOX

LEWIS two-high Hot Reversing Roughing Mill

LEWIS PRODUCTS: Two-High Mills • Three-High Mills • Four-High Mills • Strip Mills • Bar, Billet and Structural Mills • Plate Mills • Rod Mills • Coilers • Tables • Shears • Pinion Stands • Gear Drives • Roll Lathes

JOHN

Personnel News...

John W. Price, Jr., has been appointed assistant general superintendent of Duquesne Works, U. S. Steel Corp. He succeeds **Edgar B. Speer** who has been transferred to Fairless Works as an assistant general superintendent. Mr. Price began his service with U. S. Steel at the Homestead plant in June, 1937 as a metallurgical observer. He later was placed in charge of the metallurgical laboratory handling development work and became assistant chief metallurgist in July, 1942. In October, 1945, he went to the Pittsburgh offices as bureau manager of the railroad material metallurgical division and in April, 1947, became assistant metallurgical engineer for railroad and commercial forging products. Mr. Price returned to Homestead in December, 1950 as assistant to the general superintendent. In March, 1952, he became assistant division superintendent, slabbing and plate division and in July, 1954, he was appointed superintendent of the division. Mr. Speer joined U. S. Steel in 1938 as a metallurgical observer at Youngstown District Works. Promoted successfully to Bessemer and open hearth superintendent, he was transferred in 1938 to U. S. Steel's Gary Works as assistant division superintendent of steel production. He was appointed division superintendent of steel production there in 1952 and a year later came to Duquesne Works as assistant general superintendent.

Alfred P. Miller was appointed executive vice president for the Steel Division of Merritt-Chapman & Scott Corp. He was also made executive vice president and general manager of Newport Steel Corp. Mr. Miller, who has been vice president of Newport Steel for operations since 1951, also was named to the Newport board of directors. He has been associated with the steel industry since 1916 and served with the Inland Steel Corp. for 27 years prior to joining Newport Steel. Mr. Miller joined the metallurgical department of the Mesta Machine Co. in 1916, and progressively was advanced to the roll casting and open hearth departments. He was named superintendent of the open hearth department in 1919 and served in that post until 1923, when he joined the Inland Steel Co. as superintendent of the Number 2 open hearth department of the Indiana Harbor Works. He became assistant general superintendent of the Indiana Harbor Works in 1937, and was named general superintendent in 1945. He joined Newport in 1951 as vice president in charge of operations.

John W. Leber has been appointed division industrial engineer—raw materials in Jones & Laughlin Steel Corp.'s general office, Pittsburgh, Pa. He formerly was mine industrial engineer at J&L's Michigan Ore Division, Negaunee, Mich. Mr. Leber replaces **Charles E. Woll** who has been named assistant works industrial engineer at J&L's Pittsburgh Works Division.

Howard J. Davis was elected president of the Calumet Steel and Franklin Steel Division of Borg-Warner Corp. He succeeds **W. B. Caldwell** who has retired. Mr. Davis previously was assistant to the president of the Colorado Fuel and Iron Corp.

Gwilym A. Price, president of the Westinghouse Electric Corp. since January, 1946, was elected chairman and president at the meeting on August 24 of the Board of Directors. Mr. Price continues as chief executive officer, a responsibility he has carried throughout his term as president. The board chairmanship at Westinghouse has not been occupied since 1951. The directors elected **Mark W. Cresap, Jr.,** to serve as executive vice-president and deputy chief executive officer. Since April, 1951, Mr. Cresap has been vice-president and assistant to the president of Westinghouse. He was also elected to the company's Board of Directors and to the Executive Committee. **Latham E. Osborne** was elected vice-chairman of the board. Mr. Osborne has been a board member since 1953. **John K. Hodnette,** formerly vice-president in charge of the company's apparatus products divisions, was elected vice president-general manager, responsible for supervision of the operations of all of the product groups. Mr. Hodnette also was elected to the Board of Directors. The position left vacant by Mr. Hodnette's promotion, directing manufacture and distribution of basic electrical equipment for utility and industrial applications, was filled by the appointment of **A. C. Monteith,** since 1948 the vice-president in charge of engineering

JOHN W. PRICE, JR.

ALFRED P. MILLER

JOHN W. LEBER

HOWARD J. DAVIS

CARL CLAUS

FRANK L. WILHELM

CLARE B. CARLSON

FRANK BLUM

and research. Succeeding Mr. Monteith in that post is **Dr. John A. Hutcheson,** director of the Westinghouse Research Laboratories since 1949, and a vice-president since 1950. A new director of research will be appointed later.

Carl Claus has been named director of staff of the Babcock & Wilcox Co. Mr. Claus joined B&W in 1931. After several production assignments in the Boiler Division at the Bayonne, N. J. and Barberton, Ohio works, he was made assistant superintendent at Bayonne when that plant was partially reactivated in 1937. He was transferred to the Refractories Division and appointed superintendent of the Augusta, Ga. works in 1938. In 1953 he was transferred to the New York office as executive assistant in charge of manufacturing and sales for the Refractories Division.

Frank L. Wilhelm has been elected assistant vice president of the Rust Engineering Co. Mr. Wilhelm joined the Rust organization in 1936 as a field office manager, and later served as superintendent on a number of the company's major construction projects. In 1949 he was promoted to project manager.

Clare B. Carlson was named manager of the Electrothermic Division of Pittsburgh Lectromelt Furnace Corp. Mr. Carlson comes to Lectromelt from Dow Corning Corp. Mr. Carlson was also associated for four years with Pittsburgh Consolidated Coal Co. Later he served for nearly three years as furnace room superintendent for Pittsburgh Metallurgical Corp.

Frank Blum has been named general sales manager, P&H Industrial Division of Harnischfeger Corp. Mr. Blum also becomes a member of the executive committee. Mr. Blum is a veteran Harnischfeger member, joining the corporation in 1929. He has been sales manager of the P&H Overhead Crane Division since 1942.

Captain Max Schreiner (USN retired) has been appointed executive engineer of Elliott Co. In this capacity, he is responsible for all engineering of the company's turbine, compressor, supercharger, and general apparatus divisions.

Lewis E. Wallace formerly of Rotary Electric Steel Co., has joined Northeastern Steel Corp., as superintendent of roll shop, guide and roll grinding department.

Donald N. Watkins has resigned as vice president of Continental Foundry & Machine Co., effective August 1. He will now devote his time to his position as chairman of Steel Publications and other interests.

John Glasgow, formerly assistant to the superintendent, open hearth department, at Cleveland Works Division of Jones & Laughlin Steel Corp., has been promoted to superintendent of the open hearth department. **Charles P. Vorhes,** formerly assistant superintendent, safety and welfare department at J&L's Aliquippa Works, has been named supervisor of safety and employment at the Cleveland plant. Mr. Glasgow replaces **Carl P. Guthrie,** who now will serve as consultant to the superintendent, open hearth department. Mr. Vorhes succeeds **Oscar B. Kent,** who has retired.

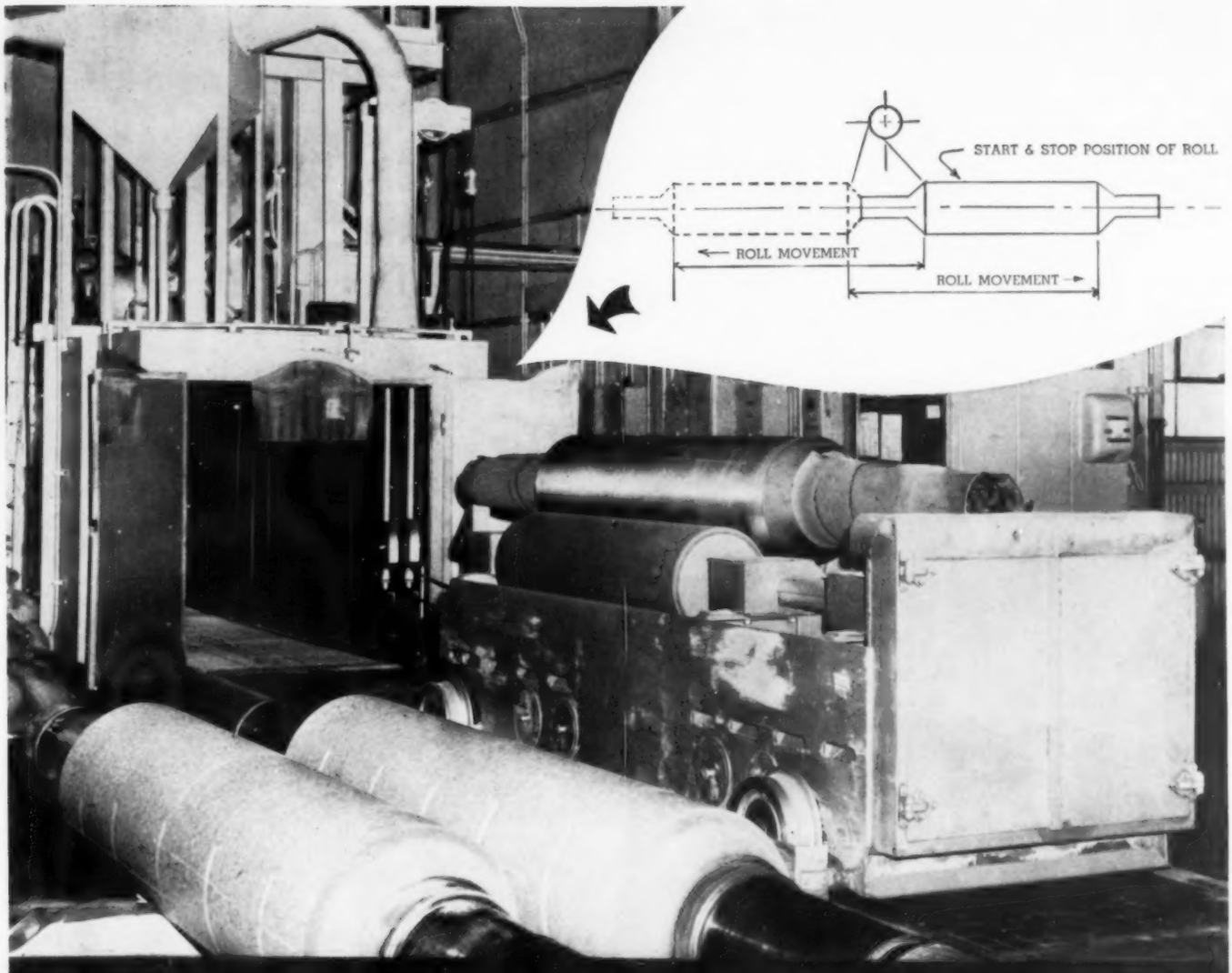
Chalmers C. McElvain has been named administrative assistant to the manager at the Baltimore works of Armco Steel Corp. and will also continue to serve as works industrial engineer. **Leslie R. Swartout** has been appointed assistant works engineer and **Milton Lankham** has been promoted to the position of senior mechanical engineer.

William J. McBride has been appointed assistant general superintendent, Green River Steel Corp. He was formerly assistant superintendent, rolling mills.

Harold R. Dueber was appointed superintendent of the transportation department of Republic Steel Corp.'s Warren District steel plants.

Charles F. Sawyer was named works manager of the Latrobe, Pa., mill of Vanadium Alloys Steel Co., replacing **Frank Moberg,** who has retired.

Norman C. Michels was named vice president-engineering of the Tennessee Coal & Iron Division of U. S. Steel Corp., effective September 1. He succeeds **Arthur B. Haswell** who retires on that date after 53 years of



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And Wheelabrator gives a uniform etch because the roll rotates and moves laterally at uniform speed as it passes under the entire blast pattern in both directions as indicated in the sketch above. You never get any "barber pole" effect with a Wheelabrator.

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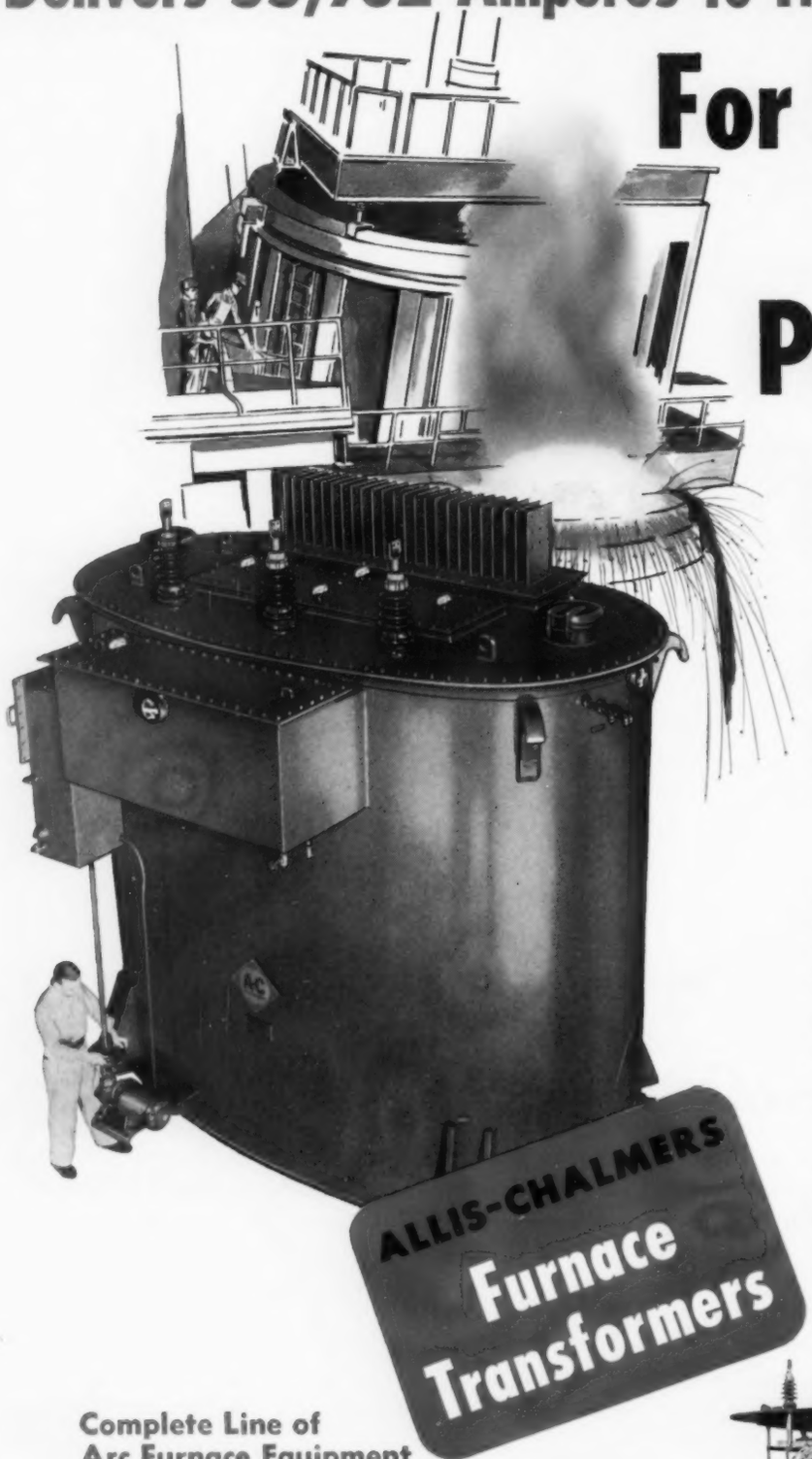
First in Mechanical Descaling

Delivers 33,962 Amperes to The Timken Company

For Specialized Steel Production



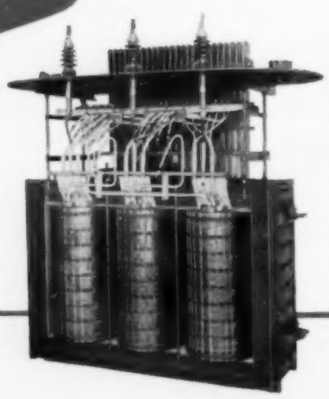
This is one of three arc furnace transformers built by Allis-Chalmers for The Timken Roller Bearing Company, Canton, Ohio, plant.

The repeated daily short circuits encountered in arc furnace operation require exceptionally rugged transformers that can provide reliability over long periods. That's one reason Allis-Chalmers furnace transformers are chosen for jobs like this. They have served many furnaces for as much as 25 to 30 years.

Design Features

Extremely heavy supports brace the coils against short circuit stresses in these transformers. Skillful insulation techniques protect windings from overvoltages due to wide tap range. Some of these transformers have been built with a range of operating voltages of several times the minimum secondary voltage.

The tap changer has specially designed contacts to provide for long life regardless of numerous daily tap changes. The mechanism is located in a separate compartment to facilitate inspection. It can either be motor driven or manually operated or both.



Rugged Core and Coil Assembly design is based on Allis-Chalmers more than 45 years' experience building arc furnace transformers. Unit must withstand repeated short circuits.

Complete Line of Arc Furnace Equipment

In addition to furnace transformers in ratings up to the largest demanded by expanding arc furnace operation, Allis-Chalmers also builds electrical control, circuit breakers, and auxiliary transformers. Next time you need new or replacement arc furnace electrical equipment, consult the Allis-Chalmers office nearest you or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4750

ALLIS-CHALMERS

service with TCI. Mr. Michels was employed by U. S. Steel in 1941 as special engineer at the Carnegie-Illinois Steel Corp., Pittsburgh, and was transferred the following year to Carnegie-Illinois, Gary, Ind., operations as an expediter. He became assistant project engineer there in 1944. In 1947 he joined Laclede-Christy as a chief engineer and subsequently assumed the added responsibilities of manager of operations. He rejoined Carnegie-Illinois in 1950 as a planning engineer and advanced to the position of chief engineer-project development for U. S. Steel at Pittsburgh on January 1, 1952. He was appointed assistant vice president in charge of engineering at TCI on December 1, 1954.

Louis A. Ringman has been appointed fabrications manager at the Claymont, Del., plant of the Colorado Fuel and Iron Corp.'s Wickwire Spencer Steel Division.

James C. Barnett has been named plant engineer at the Boston Works of Allis-Chalmers Manufacturing Co., succeeding **N. William Morelli**, who has been transferred to a similar post at the company's Terre Haute, Ind., Works.

Alexander Shearer has been appointed assistant to the operating vice president of Wheeling Steel Corp. He has been associated with Wheeling Steel since 1922. Since 1952 he has served as manager of production.

Theodore L. Funk has been named assistant chief engineer of McDowell Co., Inc. Prior to joining McDowell, he was for a number of years associated with Jones and Laughlin Steel Corp., serving in various capacities including that of resident engineer of the firm's Cleveland works. He also served as a project engineer at Surface Combustion Corp.

C. H. Case has been appointed a division manager for Kaiser Engineers Division of Henry J. Kaiser Co. Mr. Case joined the Kaiser organization in 1948 as a project engineer. His prior engineering experience included work in the chemical and steel industries in the United States and abroad.

Albert S. Redway was elected president of Rockbestos Products Corp. He replaces **Carl B. Ely**, who has retired.

David Swan has been made director of research of Metals Research Laboratories, Electro Metallurgical Co., a division of Union Carbide and Carbon Corp. Mr. Swan has been with Union Carbide since 1946 when he joined the Electromet Research Laboratories in Niagara Falls. In 1947 he was transferred to the New York offices as research engineer. He moved back to Niagara Falls in 1952 when he was appointed assistant director of research for the Laboratories.

R. E. Rogers, formerly manager of the Los Angeles branch of the Foxboro Co., has been appointed manager of the instrument company's West Coast sales activities. Replacing Mr. Rogers as Los Angeles branch manager is **E. W. Pitt** who has transferred from the Shreveport, La., office where he has been branch manager since 1948. **D. P. Thomas**, industrial engineer, has been promoted to branch manager at Shreveport. In other new appointments, **M. F. Parr** has been made regional engineer at San Leandro; **C. E. Heegard** has been added as industrial engineer at Los Angeles; and **C. J. DeVilbiss** has transferred from Dallas to serve as industrial engineer at Shreveport.

Edward J. Richardson was named manager of the tubular products and cold finished bar division of Joseph T. Ryerson & Son, Inc. He succeeds **Allen P. Beckloff** whose promotion to manager of the Ryerson plant in Boston was previously announced.

C. Guy Rivers has been appointed technical sales engineer in the Philadelphia area, southern N. J. and the state of Del. for E. F. Houghton & Co. Named as hydraulic engineer in the Central New England area is **Edward L. Babcock.**

Dr. W. A. Thomas has been appointed vice president in charge of engineering for the Electric Products Co. Other appointments include: **J. R. Williams** to vice president in charge of manufacturing; **R. J. Berry** to secretary-treasurer; and **R. A. Morey** to assistant secretary and assistant treasurer.

E. B. Thompson was promoted to vice president, sales, of the Torrington Co. Other promotions an-

ALEXANDER SHEARER

THEODORE L. FUNK

C. H. CASE

ALBERT S. REDWAY

Stop hunting trouble with a screwdriver!

You can have

PRACTICAL PREVENTIVE MAINTENANCE

KEEP PRODUCTION ROLLING

SPOT TROUBLE BEFORE PRODUCTION STOPS

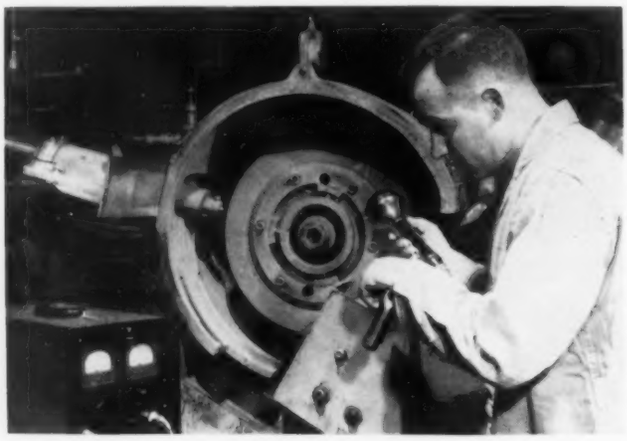
REPAIR WITHOUT COSTLY DISMANTLING

with

IRD *Vibration Analyzers*

that

YOUR MECHANICS CAN USE.



Take, for instance, your roll grinding—a large bearing manufacturer cut grinding wheel balancing for each of its hundreds of grinders from 3 hours to 20 minutes, reduced rejects due to chatter by 15% . . . A crankshaft producer balances its grinders in 10 minutes instead of 2-4 hours, cuts dressing diamond usage by 30%—and troubleshoots quickly by locating and measuring imbalance in all rotating parts *before trouble occurs.*

And—IRD Vibration Analyzers are taken *to* the machines—to find and correct trouble without expensive downtime.

IRD Vibration Analyzers make preventive maintenance practical on machine tools, blowers, motors, belt and direct drive systems, generators, turbines, fans, pumps—wherever parts rotate.

Ask for an IRD engineer to demonstrate The Key To Practical Preventive Maintenance.

IRD *International Research and Development Corporation*
Box 1707, Columbus 16, Ohio, U.S.A.

nounced were: **Donald E. Lewis,** sales manager, Bearings Division; **Raymond G. O'Connell,** assistant sales manager, Bearings Division and **Richard A. Ramsey,** manager of Detroit, Mich., office.

E. H. Hughes, manager of the sales order department of the Timken Roller Bearing Co., has been named to the newly-created post of assistant to the

E. H. HUGHES

sales director. The appointment of **J. L. Brown** and **Don M. Brown** to the posts of assistant manager of the sales order department and manager of the allocations department respectively was also announced.

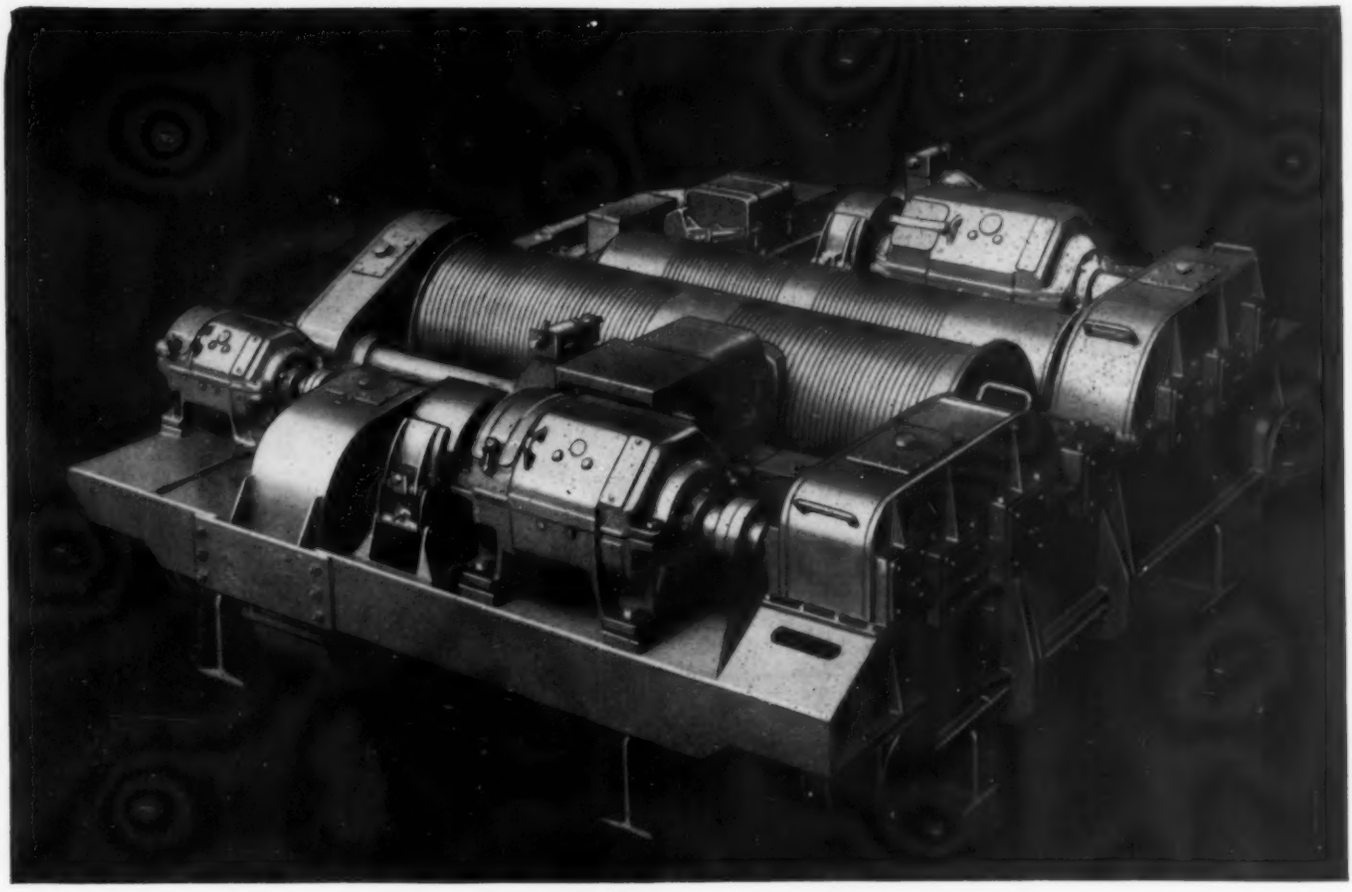
J. E. Brinckerhoff has been named manager of the Refractories Division of the Babcock & Wilcox Co., succeeding **A. M. Kohler** who retired August 1.

J. R. Woodruff, formerly Pacific Coast district manager of the Electric Controller & Manufacturing Co. has been named assistant sales manager. Succeeding

J. R. WOODRUFF

him in Los Angeles is **C. A. Mitchell, Jr.,** who has been district manager in Houston. **O. J. Archer,** who has been sales representative in Washington, is appointed district sales manager in Houston.

Frank Soles was appointed works manager, in charge of all plant operations at Delta-Star Electric Division,



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FOR HEAVY DUTY MILL TYPE CRANES

"Simple Design is Sound Design"

We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A.I.S.E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

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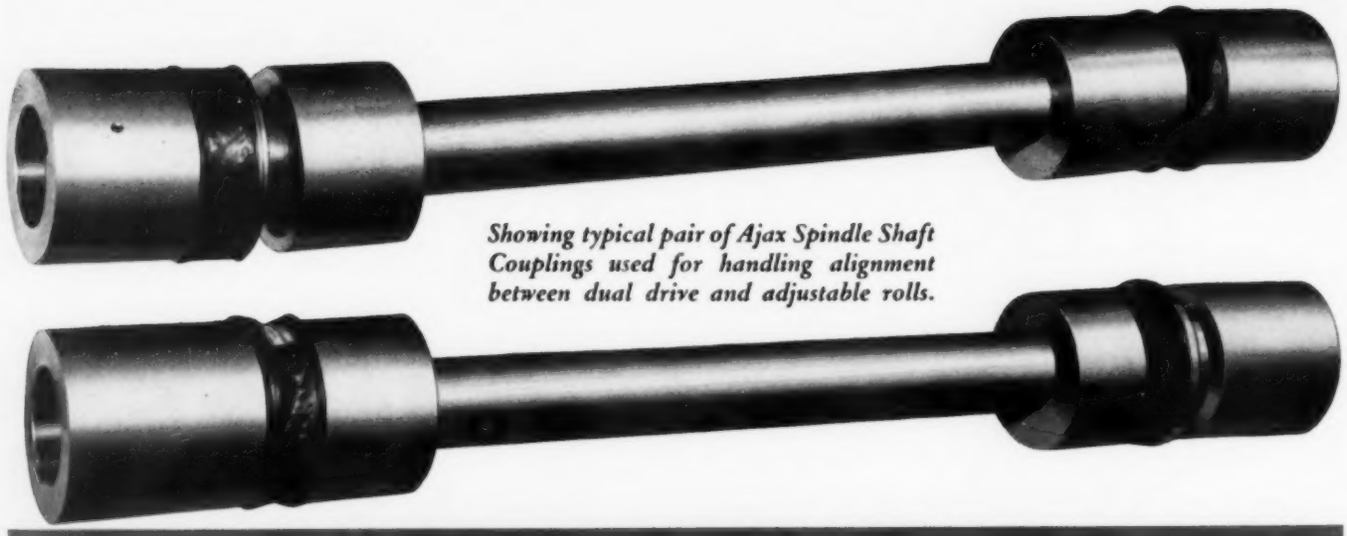
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes



Showing typical pair of Ajax Spindle Shaft Couplings used for handling alignment between dual drive and adjustable rolls.

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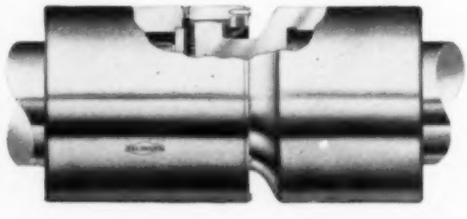
AJAX DIHEDRAL SPINDLE SHAFT COUPLINGS

Improve Performance Standards of Rolling Mills

Angular offset drive has always been a plague of the industry. The performance of Ajax Dihedral Spindle Shaft Couplings, introduced 5 years ago, has re-written the specifications and production records of rolling mills.

Uniform peripheral speed, ability to handle maximum misalignment with tool clearance limited to lubrication film requirements, elimination of vibration, and minimum maintenance are reasons why rolling mill builders and operators are welcoming Ajax Dihedral Couplings with open arms.

They deserve the serious consideration of every executive directly or indirectly concerned with increasing production. Write for Ajax Bulletin 58 for the latest information on Spindle Shaft Couplings.



Cut-away view of Ajax Dihedral Spindle Shaft Coupling showing arrangement of gear teeth.

AJAX FLEXIBLE COUPLING CO. INC.

REPRESENTATIVES IN PRINCIPAL CITIES

WESTFIELD, N. Y.

H. K. Porter Co., Inc. Prior to joining Delta-Star he conducted his own consulting engineering service.

Herbert H. Muir, hoisting and unloading equipment sales engineer for the Mead-Morrison Division of McKiernan-Terry Corp., has retired after 35 years of service.

Robert P. Hindman has been named assistant to the general superintendent of Armco Steel Corp.'s Butler works. **Samuel J. MacMullen** succeeds Mr. Hindman as works metallurgist of the Butler plant.

A. Richard Brown has been appointed secretary to the vice president in charge of operations, Youngstown Sheet and Tube Co.

C. R. McCloskey formerly associated with Salem Engineering Co., has been named president of Industrial Furnace Co. The company has recently moved to permanent offices in the Farmers National Bank Building, Salem, Ohio.

William M. Taylor has been appointed assistant general manager of the Laclede-Christy Division of H. K. Porter Co., Inc.

C. S. Wiedman, product and process development engineer, Carboloy Department of General Electric Co., has been appointed manager of carbide products development engineering. In his new post, he will be responsible for directing the metallurgical development of carbide materials and related processes.

Arthur C. Sanderson has been named traffic manager for Middletown, Ohio, works of Armco Steel Corp.

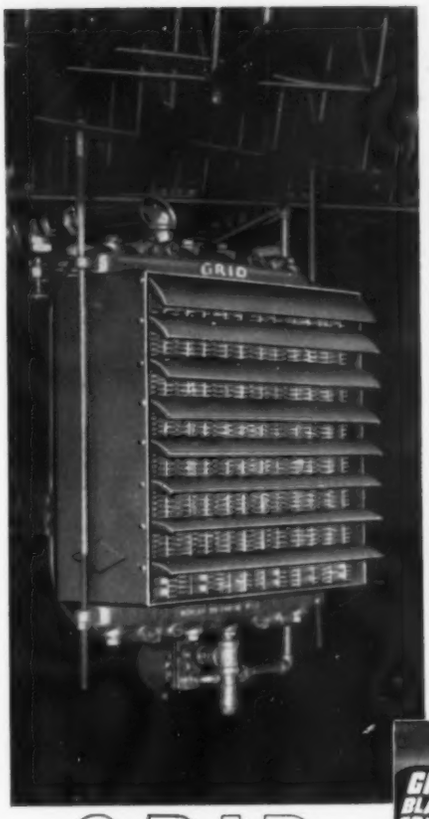
Obituaries

E. Von Hambach, research and development engineer of the Carpenter Steel Co., died August 11. He was 62.

A. E. Abel retired chief engineer of the Valley Mould and Iron Corp., died August 3.

John D. Hysong, Chicago District sales manager for Basic Refractories, Inc., died on July 23. Mr. Hysong joined Basic Refractories in 1942 as service engineer. Prior to that time he had served in various capacities in the open hearth at Carnegie-Illinois Steel in Homestead, Pa., later at Braddock, Pa., as first helper and as melter foreman. In 1941 he became open hearth rail and heat inspector for the R. W. Hunt Co.

Howard T. DeRemer, works manager, Selas Corp. of America, died August 28. Mr. DeRemer joined Selas in 1951, coming from the Philadelphia Gear Works Co., where he was assistant plant superintendent. He previously was active as an industrial management consultant.



hang 'em

...and

forget 'em

Eastern Stainless Steel Corp. uses GRID BLAST COILS for sheet drying.

GRID

UNIT HEATERS AND BLAST COILS

Trouble-free heating service in the **MAJOR STEEL MILLS**.... *since 1929*

...NO Maintenance or Repairs

Maintenance cost conscious steel management men turn to GRID for relief from the continuous expense of heating failures experienced with ordinary unit heaters. GRID Units installed in steel mills in 1929 are still operating today . . . without maintenance or repairs . . . the only attention needed has been an occasional oiling of the motor. No other unit heater can approach this record — the outstanding reason for GRID'S wide acceptance in the nation's leading steel mills since 1929. It's a record made possible because

GRID'S All-Cast construction having similar metals in contact with steam prevents electrolytic corrosion.

GRID'S ability to withstand steam pressures up to 250 p.s.i.

GRID'S low outlet temperatures, proper fan sizes and motor speeds assure delivery of warm, comfortable air in ample volume directly to the working level, where it is needed . . . no stratification of warm air at the ceiling to waste your fuel dollars. There are units cheaper than GRID, but there are none better. You start saving money the day you install GRID Unit Heaters.

Write today for the complete GRID story. Also, ask for complete information on GRID Blast Coils (Catalog BC-1049). Ask for booklet "CORROSION IN UNIT HEATERS" . . . it's yours upon request.

D. J. MURRAY MANUFACTURING CO.

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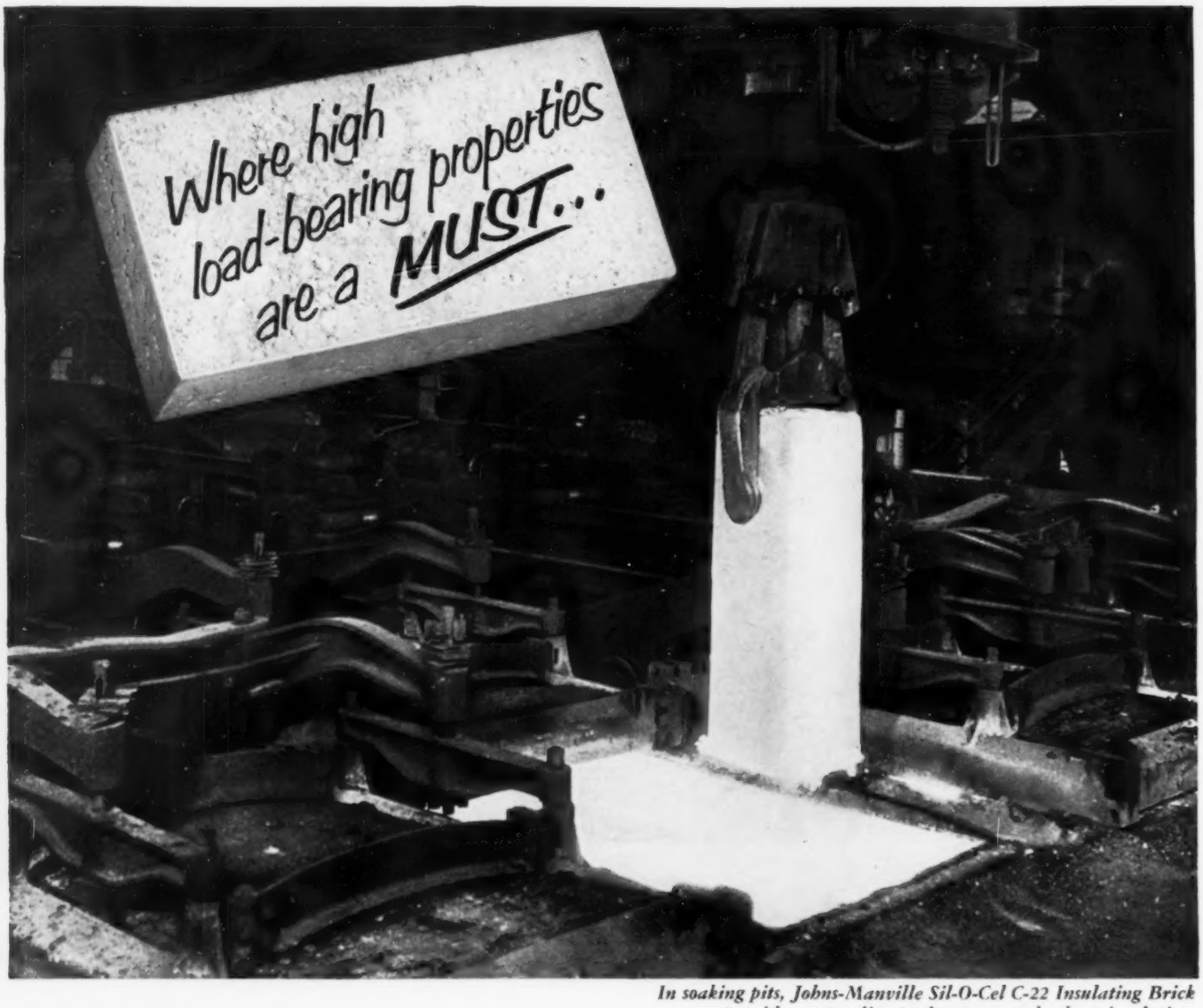


In soaking pits, Johns-Manville Sil-O-Cel C-22 Insulating Brick provide outstanding performance as back-up insulation.

Specify

Johns-Manville SIL-O-CEL C-22 Insulating Brick

the diatomaceous silica brick that retains its high cold crushing strength of 700 psi throughout normal service range

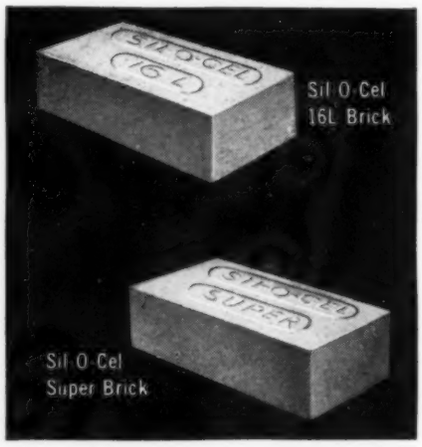
Because of its exceptional strength Sil-O-Cel C-22 Insulating Brick has gained wide acceptance as an all-purpose insulating brick. It is especially recommended for soaking pits, open hearth bottoms, slab heating furnaces, hot blast stoves, coke ovens and other high temperature equipment.

Millions of microscopic cells provide Sil-O-Cel C-22 brick with excellent heat resistance up to 2000F. It has a thermal conductivity of only 1.88 Btu in/sq ft/F/hr at 1000F mean temperature. In addition, with a density of 38 lb/cu ft, it is light and easy to handle.

For direct exposure or back-up to 1600F, use Sil-O-Cel 16L Insulating Brick. This newest member of the J-M diatomaceous silica insulating brick family has *less than 0.1% reversible thermal expansion at 1600F.* Conductivity is 1.07 Btu in/sq ft/F/hr at 1000F mean temperature with a density of 33-35 lb/cu ft. Cold crushing strength is 350 psi. Sil-O-Cel 16L serves equally well as back-up insulation or exposed refractory lining.

For back-up at higher temperatures, specify Sil-O-Cel® Super Insulating Brick with an unusually high temperature limit of 2500F.

Write today for further information on Sil-O-Cel Insulating Brick and Insulating Fire Brick. Ask for Brochure IN-115A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ontario.



JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *first in* INSULATION

MATERIALS · ENGINEERING · APPLICATION

Leveling Machine
for hot, mild steel
¼" to ⅝" x 100" wide

BIRDSBORO Plate levelers are designed, engineered and built to your requirements

Designers and Builders of:

STEEL MILL MACHINERY
HYDRAULIC PRESSES
CRUSHING MACHINERY
SPECIAL MACHINERY
STEEL CASTINGS
Weldments "CAST-WELD" Design
ROLLS: Steel, Alloy Iron, Alloy Steel

• When you want to improve and simplify your leveling jobs, add up all the factors you want in your new plate leveler . . . then call the BIRDSBORO ENGINEER. Let him show you the cost-saving advantages of a smooth-running, maintenance-free BIRDSBORO leveler.

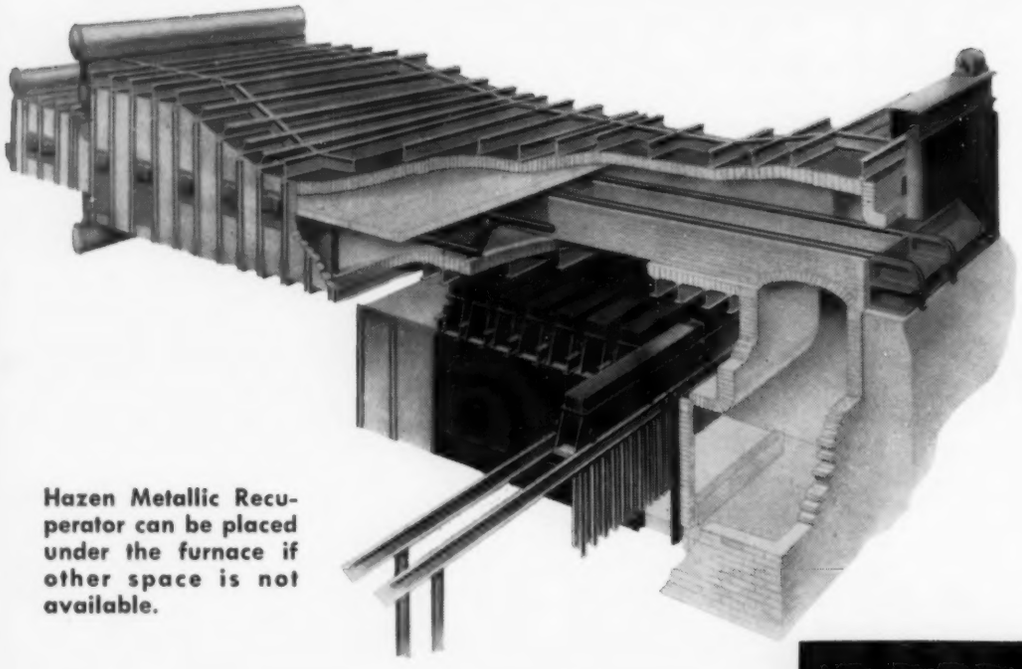
Hot or cold, heavy or light plate leveling jobs and all the problems connected with them will be met by the diversified experience of BIRDSBORO personnel — designers, engineers, and production men. Put them to work for you. BIRDSBORO is the answer for leveling.

MM-44-55

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. Offices in Birdsboro, Pa. and Pittsburgh, Pa.

Hazen Metallic Recuperators installed above 4 new Slab Reheating Furnaces at Fairless Works, United States Steel



Hazen Metallic Recuperator can be placed under the furnace if other space is not available.

the only 100% American Metallic Recuperator

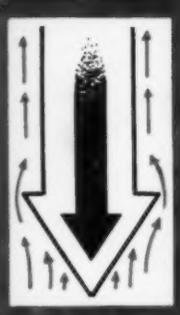
Consult us about improving the production and economy of your furnace operations

NOW IN OUR NEW PLANT

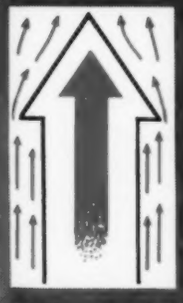
HAZEN *Metallic* RECUPERATORS

improve FURNACE production and economy

BY TAKING ADVANTAGE OF *"what comes naturally"* IN THE FLOW OF FLUE GASES FROM THE FURNACE TO THE RECUPERATOR



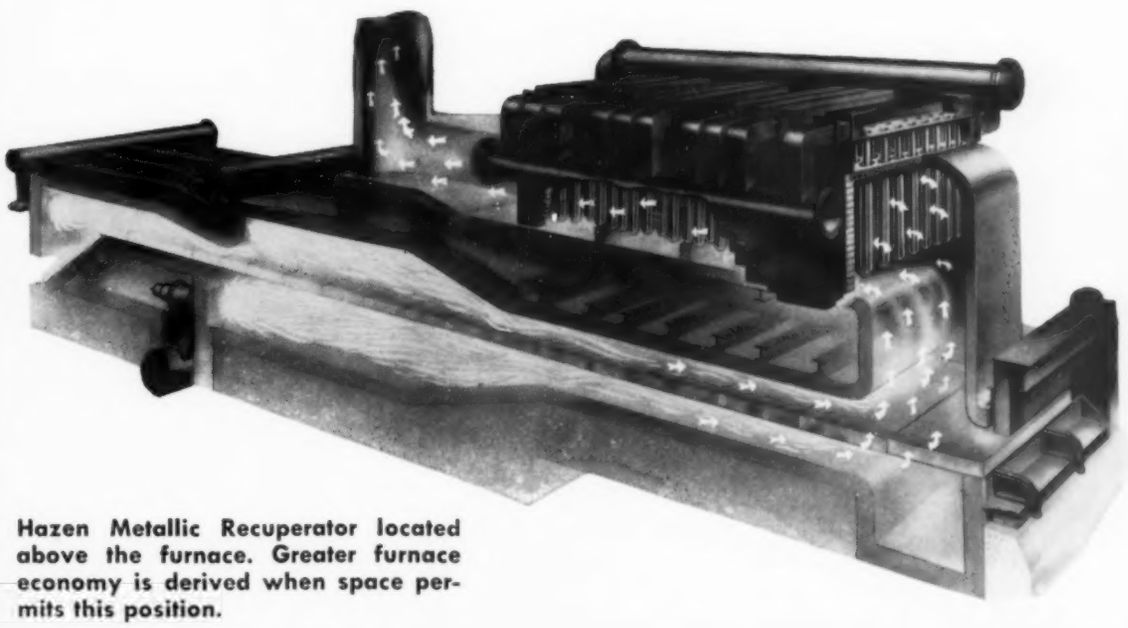
CONVENTIONAL APPLICATIONS
RESIST
THE NATURAL UPWARD
FLOW OF GASES



IMPROVED APPLICATIONS
ASSIST
THE NATURAL UPWARD
FLOW OF GASES

HAZEN RECUPERATOR FEATURES:

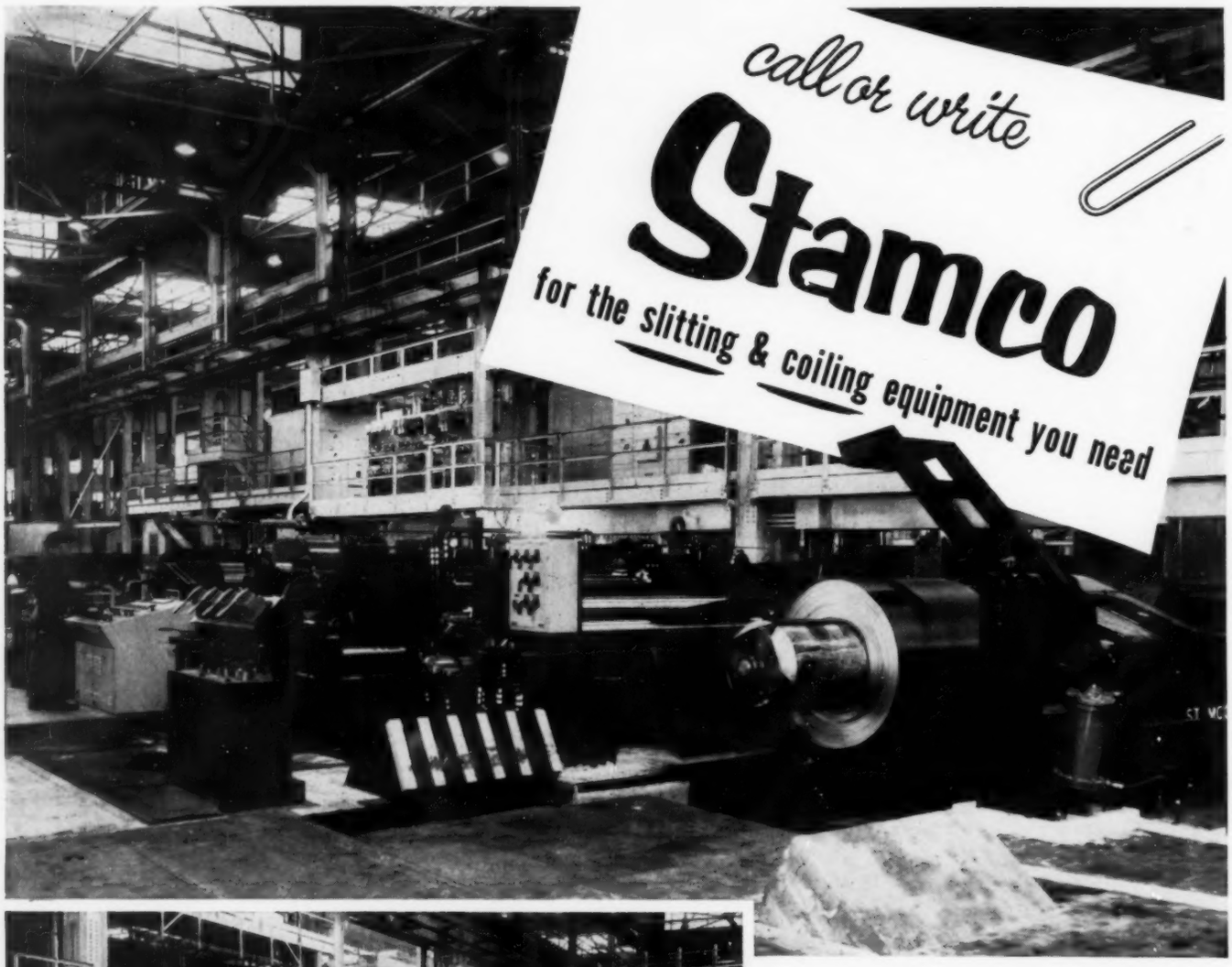
- Entirely made in U.S.A. All inner and outer tubes made of Stainless Steel.
- This application takes advantage of the natural upward flow of flue gases.
- Increased preheat . . . due to the availability of a larger percentage of flue gases at higher temperatures.
- Economies in initial cost . . . by reducing the required amount of excavating and furnace foundation . . . by reducing the length of flue ordinarily required from furnace to stack.
- Less stack draft is required.
- Recuperator, flue and stack may be supported from steel work independent of the furnace bindings.
- Walkways may be provided around the recuperator for convenience of inspection and cleaning.
- Recuperator may be applied above an existing furnace with a minimum loss in outage time.



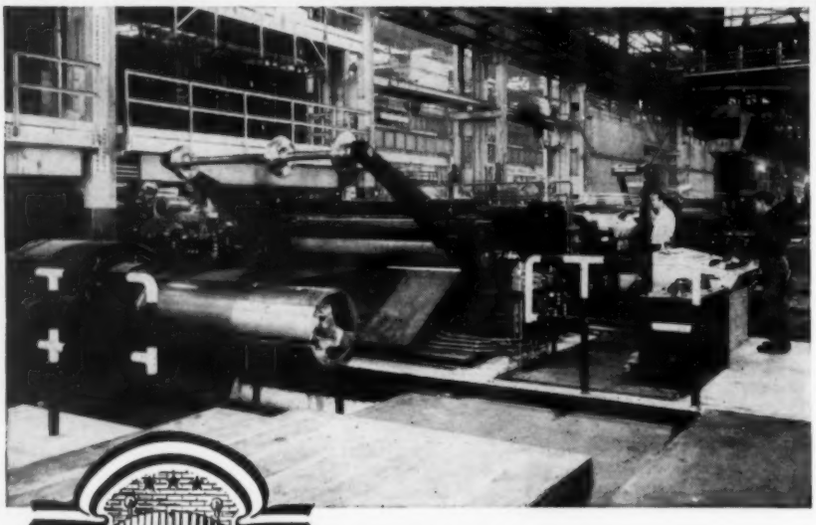
Hazen Metallic Recuperator located above the furnace. Greater furnace economy is derived when space permits this position.

HAZEN ENGINEERING COMPANY
184 Sandy Creek Road (PENN TOWNSHIP), P. O. BOX 10597, PITTSBURGH 35, PA.
Telephone CHurchill 2-1750

One of the largest slitting & coiling lines



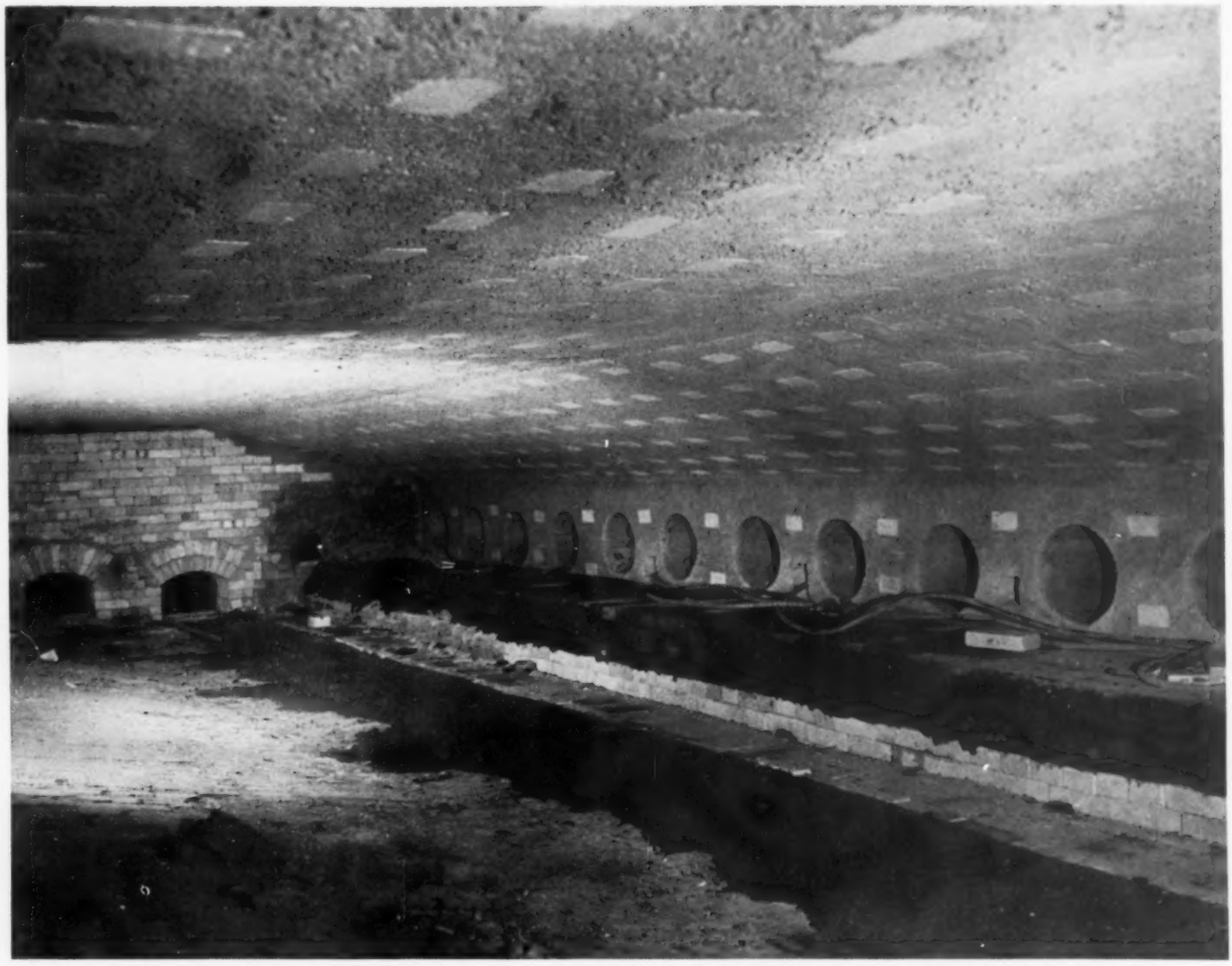
60,000 pound, 75 inch wide—
Slitting and Coiling Line



Photos show Stamco slitting and coiling unit in cold strip mill

Years of experience have given us the ability to furnish equipment to meet every slitting and coiling requirement. Bulletin SC55 gives our complete story. Ask for it on your letterhead. No obligation.

STAMCO, Inc., New Bremen, Ohio



Size of Furnace — 41′ 10″ long by 36′ 8″ wide. Ramtite Burner Wall 36′ 8″ long by 36″ high. Ramtite Roof 25′ 8″ long by 36′ 8″ wide.

Again Ramtite reduces refractory cost

...this time in roof and burner wall of rod mill furnace, Keystone Steel and Wire Company, Peoria, Illinois.

Before Ramtite was installed, it was necessary to make repairs twice a year. Complete sections were replaced in December and extensive repairs were again necessary in July of each year. Ramtite was installed in July, 1951, and in July, 1954 after 3 years service a Ramtite patch 3 ft. by 10 ft. was made in the roof at the knuckle. Since then no further repairs have been necessary. Ramtite, through extensive tests and wide use, has thoroughly proved it does a better job.

RAMTITE is our Business, Not Our Sideline. Over 35 years experience in Plastic and Castable Refractories qualifies us as experts in design, construction and application of these products. Write for **free** bulletin or call your local RAMTITE office for information and service.

Can You Afford Not to Use Ramtite?

We Will See You At the Convention

THE Ramtite CO.

DIVISION OF THE S. OBERMAYER COMPANY

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send items checked

☐ Bulletin on Castable and Gunning Refractories
☐ Steel Plant Bulletin

Company Name .....
Attn. Mr. ..... Title .....
Address .....
City ..... Zone .... State .....

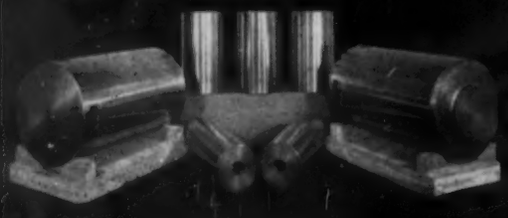
This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

5844

THE RED CIRCLE *is your Guarantee!*

RED CIRCLE Rolls ALLOY-CHILLED

18" 3 Hi Bar Mill



Chilled Iron Hydraulic Rams

Hyde Park Red Circle Rolls are known by the red circle on the end of the roll—it is the mark of quality.

For over fifty years Hyde Park Red Circle Rolls have been giving top production and achieving new endurance records in many mills throughout the country.

A Red Circle Roll for every purpose.

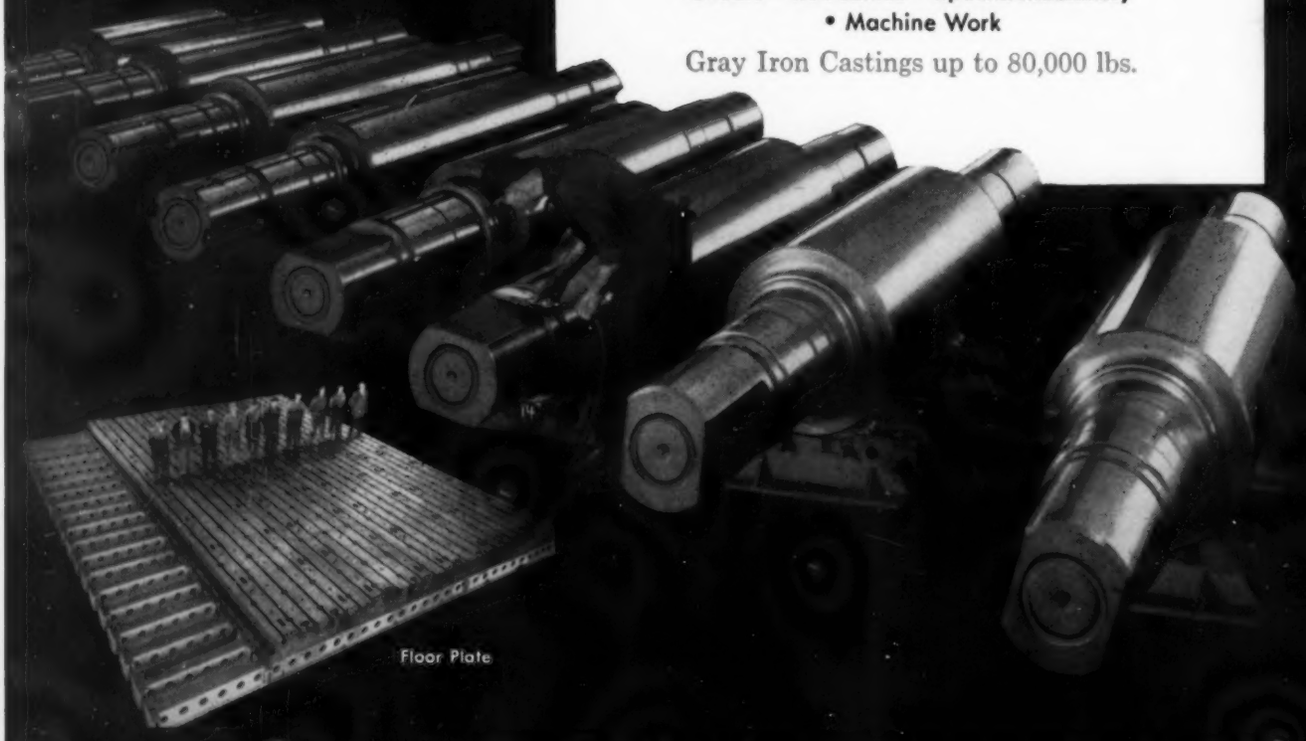
Chilled Rolls • Alloy Iron Rolls • Moly Rolls • Nickel Chilled Rolls • Grain Rolls • Cold Rolls • Sand Rolls Chilled Hydraulic Rams

Rolling Mill Equipment

Hyde Park Rolling Mill Equipment is extra rugged to withstand the increasing demands of production. Our engineers will be glad to co-operate with you regarding any special mill equipment.

Bar Mills • Merchant Mills • Sheet and Strip Mills • Pinion Stands • Roller Tables • Reduction Drives • Stretcher Levellers • Guillotine Shears • Sheet Mill Shears • Roll Lathes • Special Machinery • Machine Work

Gray Iron Castings up to 80,000 lbs.



Floor Plate

Hyde Park FOUNDRY & MACHINE CO.

HYDE PARK, WESTMORELAND COUNTY, PITTSBURGH DISTRICT, PA.

The largest order

ever issued for tin-plating generators
has been placed by
The Youngstown Sheet and Tube Company.

These will be furnished by
Chandeysson Electric Company, St. Louis.

The order was negotiated by
Lamkin Brothers Company, Pittsburgh.

Pickling tank and wash tank at Laclede Steel Company. Note the rolls fabricated from tough corrosion- and wear-resistant Ampco Metal. Roll dimensions 31" OD x 29" ID x 36" long. Side plates 34½" OD x ½" thick with 5" ID for shaft.

Here's another roll used at Laclede. Fabricated from money-saving Ampco Metal, it handles six strips at a time.

Laclede Steel
fights wear and corrosion in its pickling line with
AMPCO METAL*

...keeps production up...costs down

Steel companies throughout the country are faced with terrific production problems. Laclede Steel Company, St. Louis, like so many others, found one answer in Ampco Metal.

Shown here is their pickling operation. The tank carries a 12% sulphuric acid solution at 200°F. The strip enters the tank and goes through the entire process via wear- and corrosion-resistant Ampco Metal rollers.

The rollers and side plates are fabricated from Ampco Grade 8 plate. Shafts and nuts are made from extruded Ampco Grade 15.

But resistance to corrosion in pickling service isn't the only important feature of Ampco Metal. It also resists wear, shock, impact. That's why so many mills use Ampco Metal screw-down nuts, slippers, wear plates, flash-welder dies.

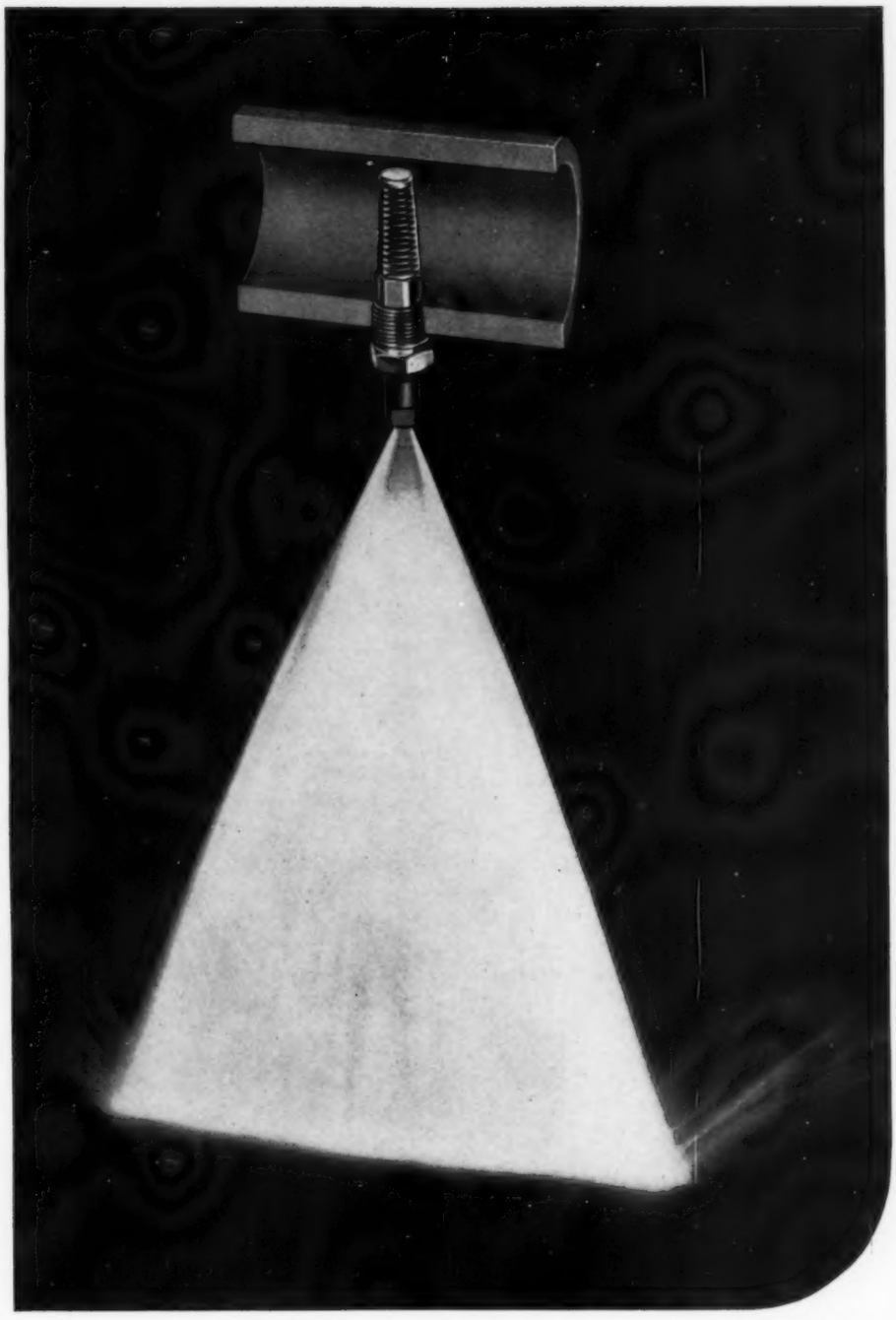
If you have a corrosion problem or a wear problem, it pays to investigate the advantages of Ampco Metal. See your nearby Ampco field engineer or write us for details.

AMPCO METAL, INC.
Dept. 15-9 • MILWAUKEE 46, WISCONSIN
West Coast Plant • Burbank, California

*Reg. U. S. Pat. Off., Ampco Metal, Inc., Milwaukee, Wis.

AMPCO®

G-11



SPRAYING SYSTEMS

descaling NOZZLES

with open, elliptical non-clogging orifice

for performance *in full measure*

you can SEE the difference

When you consider performance in all its aspects, here are spray nozzles for descaling that give outstanding full measure. Descaling itself is carried out with an efficiency as high as or higher than any other nozzle made. But equally important, Spraying Systems nozzles give you low first cost . . . **plus non-clogging design** that **reduces** the cost of down-time and maintenance to a minimum.

The thin, concentrated, uniform spray strikes with greatest possible impact for any volume and pressure . . . descales without excessive sheet cooling.

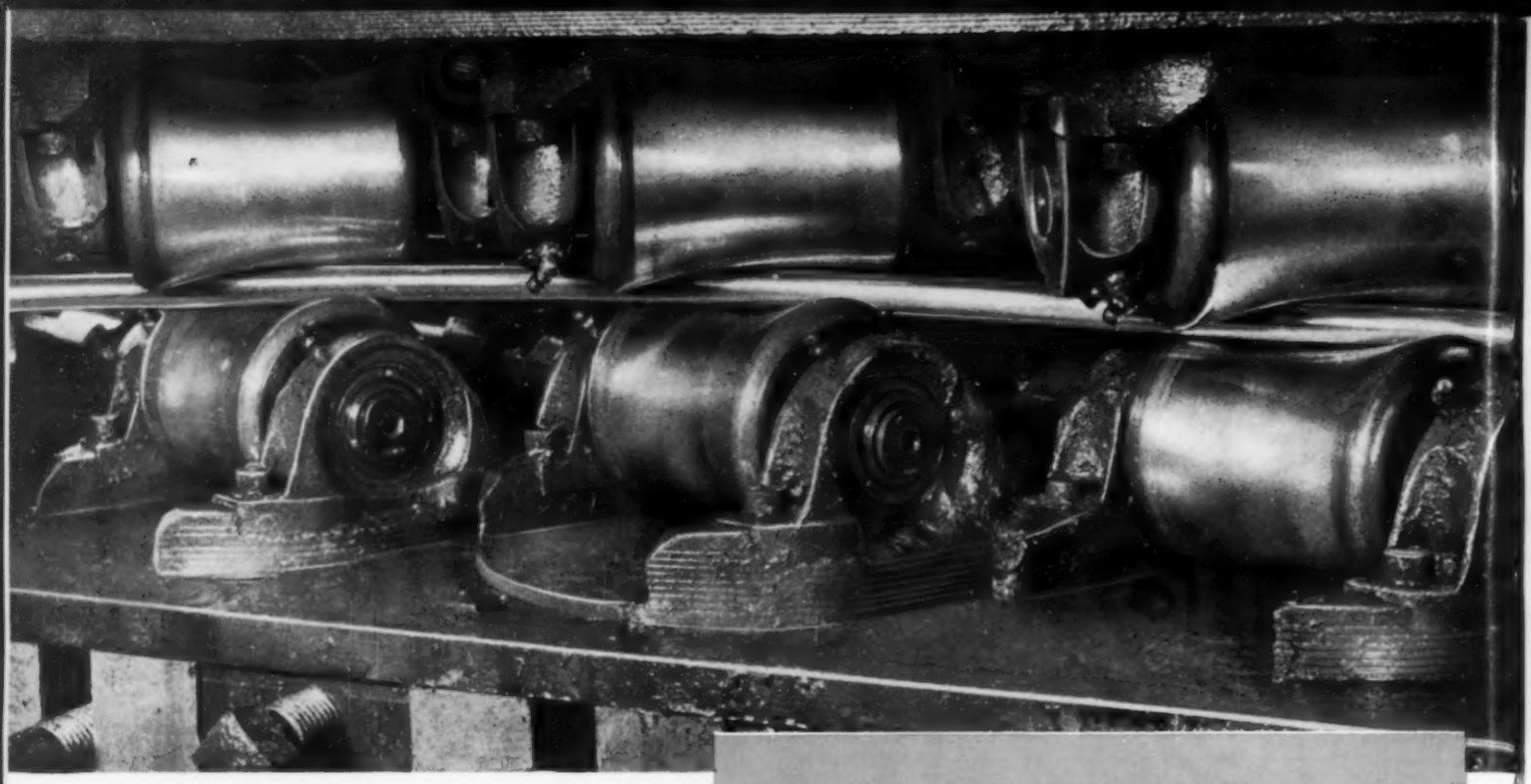
Clogging is practically eliminated by *elliptical*-shaped orifice . . . foreign matter goes right through.

CHOICE OF SIZES . . . offered in 16 different capacities . . . for every known descaling use.

Designed and manufactured by America's leading producers of industrial spray nozzles. For complete information write for Data Sheet 6120.

SPRAYING SYSTEMS COMPANY 3262 Randolph Street • Bellwood • Illinois

Spray Nozzles also supplied for such applications as Run-Out Table Cooling . . . Roll Cooling . . . Cooling Ingot Molds and many other uses. For complete information write for Catalog No. 24.



Here is the arrangement of rolls in the Mack-Hemp rotary tube straightener: six driven rolls, all adjustable for angularity, top three rolls and lower middle roll adjustable up and down. If desired, rolls can be set to produce a controlled amount of cold work or "temper" in soft tube.

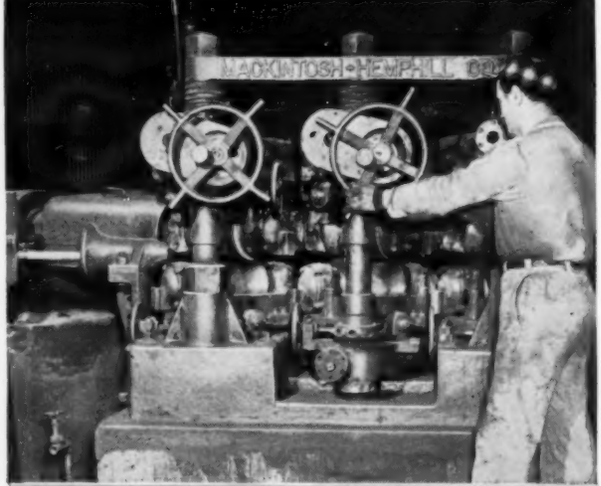
THIS UNIQUE ROTARY STRAIGHTENER GIVES YOU...

perfect tube straightness and roundness with unlimited speed

The Mack-Hemp rotary tube straightener works unhampered by tube guides at speeds limited only by tube feed and tube delivery tables. For example, the Mack-Hemp A-1, for 1″ to 3½″ O.D. tubing, has a normal production speed of 800 feet per minute. The big Model A-5, for pipe diameters up to 16″ will run at 240 fpm. Model AXY with well-designed feed and delivery tables, has straightened ¾″ brass tube at 500 fpm.

Even at these high speeds—made possible by driving all rolls—straightened tubing shows the accurate straightness and true roundness of best rotary straightening practice. O.D.'s and I.D.'s remain unchanged. And since Mack-Hemp straighteners need no guides, tube surfaces are free from blemishes.

If your present straightening equipment is slow or you're getting more than your share of customer complaints, write us today for Technical Bulletin No. 55, "How to Straighten Pipe and Tube." It's yours for the asking.



U. S. Steel's National Tube Division runs Mack-Hemp Model AO rotary straightener on continuous butt-weld steel pipe from .840″ to 2.375″ O.D. at speeds in the neighborhood of 700 fpm.

MACKINTOSH-HEMPHILL
DIVISION OF
E. W. BLISS COMPANY

Makers of the rolls with the Striped Red Wabblers

Pittsburgh and Midland, Pa.

cast mill rolls • Johnston cinder pots • rotary tube straighteners • Y-type cold mills
heavy-duty lathes • steel and special alloy castings • end-thrust bearings

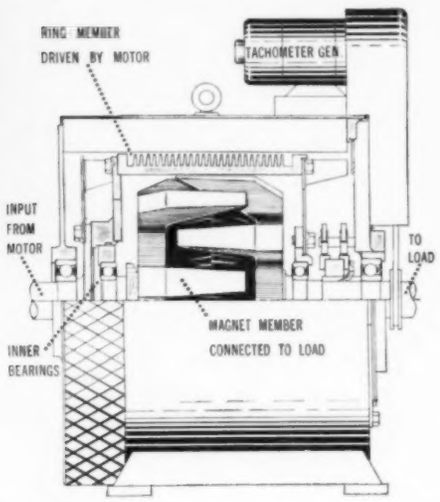
MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH · U.S.A.
BLISS

Equipment News...

ADJUSTABLE DRIVE

▲ Electric Machinery Manufacturing Co. has developed a precise adjustable speed drive.

The new unit can be coupled or belted to an existing motor to provide a speed control of plus-or-minus



two per cent for fans, centrifugal pumps and compressors, and is also designed to handle constant torque loads such as mills, conveyors, machine tools and a great many other applications. With it, the user can operate a load at the optimum speed; can change speed smoothly by means of a knob, or can control it automatically; can use the drive for test and development work; can control output of fans, pumps and compressors automatically and with a high degree of precision; can increase efficiency of fan and pump drives, decrease wear of moving parts, and eliminate shocks between the motor and load.

The system consists of (1) the speed drive installed between the motor (or other drive) and the load, (2) a wall-mounted Magnetic Amplifier Speed Control and (3) a control rheostat mounted at any convenient location. The drive can be installed with a minimum of effort because it is air cooled and requires no external cooling system, is handled like a motor, and can be either belted or coupled to the motor and load, making it adaptable even where there are tight space requirements.

The drive itself consists of a "ring member" connected to the input shaft and driven by the motor, and a "magnet member" which is mounted on the output shaft and turns the load. There is no solid physical connection between the ring and magnet member, although they are connected through two bearings (see cross-section view).

The ring member is driven at constant speed. The magnet member is excited by d-c from the control, and the d-c through the field winding sets up a magnetic attraction between the two rotating members. More field excitation increases the magnetic force between the constant speed ring member and the magnet member, so that the magnet member speed increases.

The Magnetic Amplifier Control for the drive contains no vacuum tubes or moving parts. It adjusts the speed by controlling output of the metallic rectifier supplying field excitation. Speed can be changed by turning the control rheostat knob or by means of automatic control devices such as combustion, pressure or liquid level controls. During steady-state operation, feedback from a tachometer generator mounted on top of the drive keeps load speed within plus-or-minus 2 per cent of control knob setting. Speed changes are virtually stepless.

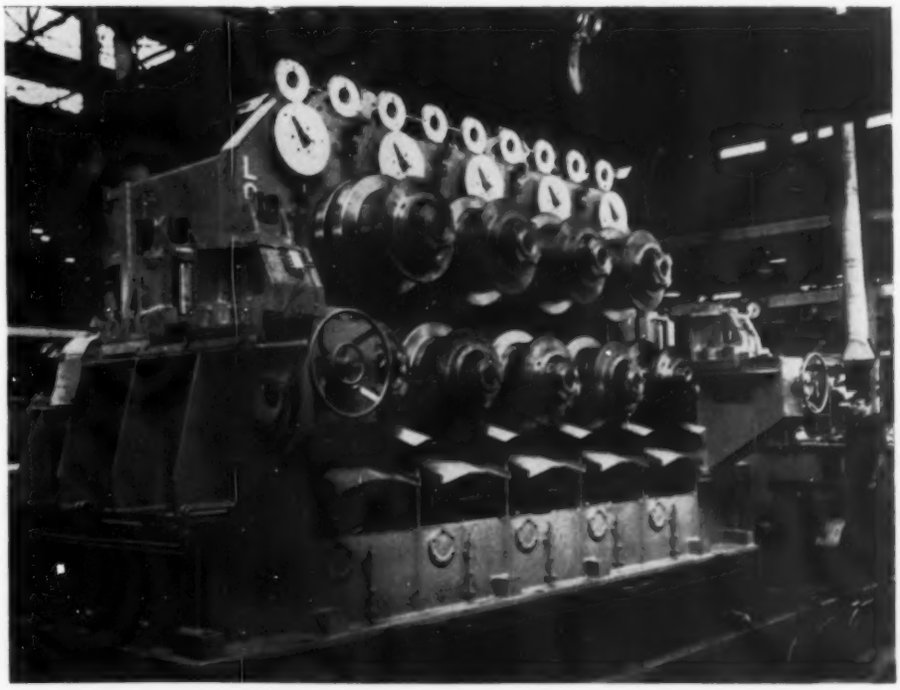
LADLE LINING

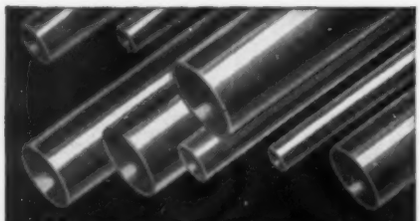
▲ A new plastic ladle lining has been introduced by J. H. France Refractories Co.

The new graphitic plastic ladle lining is recommended for use in grey iron, non-ferrous and malleable iron and steel foundries. The product is specifically recommended by the manufacturer for use in malleable iron runners and spouts, tap holes, wells, slag holes, cupolas and cupola

ROLLER STRAIGHTENERS OPERATING AT BETHLEHEM

Two heavy duty roller straighteners for wide flange beams and large T-bars have been put into operation at Bethlehem Steel Corp. These machines were designed and built by the Rolling Mill Division of Loewy-Hydropress, and feature the latest developments in this field, such as all welded construction, overhung type sleeve mounted roller assemblies for rapid roll changing, pushbutton controlled horizontal and vertical roll adjustment and grouped roller drives, incorporated in the main stand of the machine.





Now you can make
WELDED TUBES
at high speed from

STEEL
STAINLESS
ALUMINUM
BRASS
COPPER ALLOYS
NICKEL
MONEL
MAGNESIUM

Within the last few years rapid strides have been made by Yoder in widening the scope and raising the speed of cold process electric-weld pipe and tube making. In a new line of tube mills perfected by Yoder, many nonferrous metals can be induction-welded in gauges up to .154" and at speeds approaching those attained in resistance-welding steel tubes.

Further, speeds up to 250 fpm are reached in induction-welding *steel* tubing in the same gauges.

New compact Yoder "4-in-1" Welding Transformer is the last word in resistance-welding steel pipe and tubing in sizes up to 24" diameter.

More specific information, literature and estimates on request, without obligation on your part.

THE YODER COMPANY
5495 Walworth Ave. • Cleveland 2, Ohio

Electric Weld
TUBE
MILLS

slagging spouts, pouring ladles and hand ladles of all types.

Field tests and verified laboratory test reports according to the manufacturer show high "molten metal" shock resistance and high slag resistance.

DUAL SWITCH

▲ Developed by Micro Switch, a division of Minneapolis Honeywell Regulator Co., is a new single-actuated dual switch designed for a wide range of industrial control and electronic applications.

Known as 6AS13, the unit is a low-force, double-pole switch with the ability to switch two isolated circuits at the same time.

It consists of two basic switching units operated by a single roller-lever actuator. Operating point of one switching unit is field adjustable to provide either simultaneous actuation or a definite sequence of operation.

The 6AS13 is available with a variety of lever lengths, either straight or formed levers, with or without a roller. Positions of levers can be varied to left or right to fit existing applications in which a single-pole, double throw basic switch was previously used.

THICKNESS GAGE

▲ X-ray gages designed and developed by Jones & Laughlin Steel Corp. have been installed on all three electrolytic tinning lines at J&L's Aliquippa Works.

These patented gages measure the amount of tin being applied to the steel sheet during the plating operation. They provide a continuous operating check on tin coating thickness, a check that is precise, rapid, and non-injurious to the product.

For the first time, control of quality of tin plate can keep up with increasing rates of production.

The gage can measure tin coating thickness to within 6/10,000,000 of an in.

Working with the device is an instrument for recording permanently how much tin actually was applied to a particular steel coil.

The new method of measuring tin thickness makes use of the phenomenon: X-ray fluorescence.

Foreman checks distance from the fast-moving tin plate to X-ray tin thickness gage, the newest to be installed on electrolytic tinning lines at J&L's Aliquippa Works. Tin coating thickness is measured on both sides of the tin plate by the two gages, one above and one below the roll.

The X-rays are beamed at a sheet of tin plate as it leaves the line at speeds of 700 to 2000 fpm. The X-ray beam causes the steel underneath the tin coating to fluoresce, giving off X-ray radiation. This phenomenon is similar to the glow emitted by a white shirt after exposure to ultraviolet light, except that iron X-radiation is not visible to the human eye.

As the iron fluorescence leaves the steel sheet, it is partially absorbed in the tin coating so that the amount received by a radiation detector will decrease as the tin thickness increases.

The output of the detector can be used to determine the thickness of the tin coating.

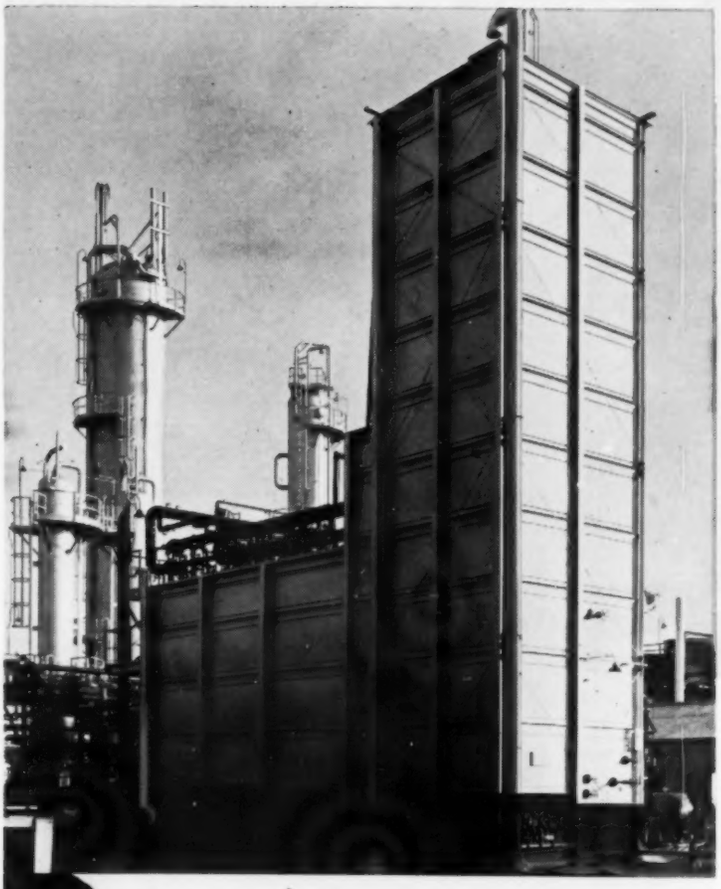
Equipment making up the gage includes an X-ray power supply and tube, a radiation detector, and necessary amplifying, indicating and recording mechanisms.

AIR SHEAR

▲ Developed by Curry Air Shear Corp., is a new air-operated shear for cutting cold ferrous and non-ferrous bars up to 1¾ in. square or round. Compared to a conventional motor-

TIMELY NEWS

For Steel Companies Contemplating Expansion—



You can install a generator to produce oxygen on location WITHOUT CAPITAL INVESTMENT!

The steel industry will expand enormously in productive capacity during the next few years. This is the recent announcement of the heads of several of the principal steel producing companies.

It goes without saying that this expansion will be accompanied by the difficult problem of raising the large amount of capital necessary. Therefore, the fact that Air Products Oxygen and Nitrogen Generators can be installed *on-location* on a lease basis *without capital investment,* should be timely news.

We provide:

Large Capacity Tonnage Generators for unlimited quantities of oxygen and nitrogen, in standard or special models, high or low pressure cycles—

and

"Packaged" High-Purity Generators, producing high-purity oxygen and nitrogen simultaneously or individually.

If you will advise us of your oxygen requirements we can give you actual figures on the savings possible with the Air Products Generator best suited to your needs.

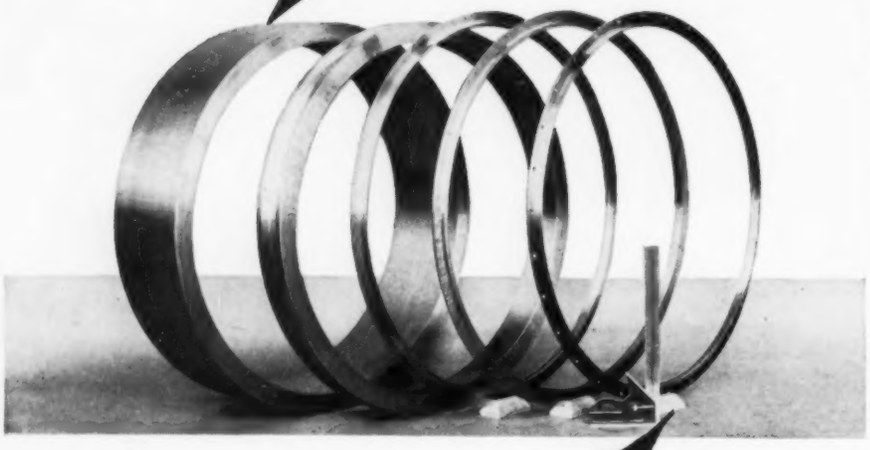
More than 100 Air Products engineers are at your service.

Low-Cost OXYGEN...NITROGEN

Air Products
INCORPORATED
Dept. P, Box 538, Allentown, Pa.

DURASPUN

CENTRIFUGALLY CAST by DURALOY



CUT and FINISHED by THE CUSTOMER

High Alloy rings for jet engines . . . we did the casting and rough finishing and the customer did the cutting and final finishing.

Centrifugally cast metal gives an exceptionally fine, dense, uniform grain structure. The strength of the metal approaches that imparted to a bar or ingot when it is hot forged. It produces an ideal metal for the tough service required of jet engine parts.

Incidentally, as evidence of our knowledge of and experience with tough alloy castings — static as well as centrifugal — the records show very few rejections by this engine manufacturer who subjected each of the many rings we furnished to his own very rigid tests.

May we suggest that you let Duraloy work on your high alloy castings — chrome iron, chrome nickel or nickel chrome? We have the experience and facilities for turning out high quality castings.

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

operated shear, the type O-SC-20 air shear weighs less and occupies only a fraction of the floor space.

The new unit operates from any standard shop air supply or compressor at pressures from 60 to 125 psi. It has no motors or gears to maintain, and with practically no wearing parts, a minimum of maintenance is required. Unlike other alligator shears, it operates only while cutting, thereby offering additional economy and safety features.

This shear is recommended by the manufacturer for cutting bar or flat stock in general production work; processing light scrap in conjunction with a baling press; cutting concrete reinforcing rods or cables, either in prefabrication operations or on the construction job; and shearing sections for laboratory tests.

It has 10 in. knives, with four cutting edges which can be adjusted by set-screws after grinding. Overloading in no way harms the equipment, since the limiting factor is the pressure in the air cylinder.

Design of the air shear is such that the operating air is thoroughly lubricated and filtered before it enters valve or cylinder. This lubricating and filtering feature further reduces maintenance costs. Also, since there are only two single grease fittings in the entire unit, very little maintenance is required.

This shear will cut 1¾ in. diameter cold mill steel at 80 psi air pressure. Normal speed is two seconds per cycle. The unit is 48 in. high, 21 in. wide and 62 in. deep and may be mounted on casters for convenient handling. Jaws, which open 4½ in. are located 36 in. above the floor.

MAGNETS

▲ A new line of rectangular electromagnetic separation magnets for removing tramp iron and other undesirable magnetic particles is announced by the Ohio Electric Mfg. Co.

Designated as Ohio Super Magnetomotive Magnets, they are used to remove tramp iron which might damage crushers and other expensive equipment.

The manufacturer states that the rectangular field of Ohio SM Magnets is specially designed for suspension over the head pulley or in a hori-

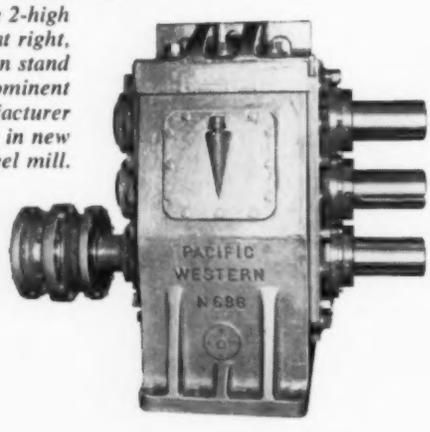
20 years of LEADERSHIP

BLOOM ENGINEERING CO., INC., 857 W. North Ave., Pittsburgh 33, Pa.

WESTERN GEAR rolling mill drives ...rugged as Gibraltar!

Western Gear 2500 HP Model S-87-MS speed reducer 5.7:1 ratio utilizing double helical staggered tooth gears.

Above, Western Gear designed double 2-high pinion stand, and at right, single 3-high pinion stand manufactured for prominent mill equipment manufacturer for installation in new Italian steel mill.



Western Gear pinion stands, gear drives and other machinery for application in steel rolling mills are backed by experience accumulated since 1888 in the design and construction of mechanical power transmission equipment of every description. It's your guarantee of ruggedness and trouble-free production day in and day out. Anti-friction bearings provide for rock-steady, vibration-free operation so essential to maintain high standards of accuracy and finish. And this same precision helps prolong the life of related machinery, too! Removable end plates on Western Gear pinion stands enable lifting entire gear train for easy inspection without removing housing from bed plate mounting.
To maintain top quality output with a minimum of downtime and overhead, insist on Western Gear drives for rolling mill application.

For recommendations on the installation of new equipment or the replacement of obsolete or worn units, write today. Our engineers will be glad to offer their help and experience. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

"The difference is reliability" • Since 1888 5570

WESTERN GEAR
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON—REPRESENTATIVES IN PRINCIPAL CITIES

zontal position over a conveyor belt. They are suspended by means of adjustable length cables.

Arrangement of the center pole and two outer poles of Ohio SM Magnets provides a practically uniform high-Gauss field across the belt, which results in effective removal of tramp iron. Thus, tramp iron located at any point across the belt is exposed to the lines of force in a uniform manner. The field is both deep and long in the direction of belt travel so that Ohio SM Magnets easily lift tramp iron out of heavy or wet burdens, or burdens moving at speeds up to 500 fpm and over.

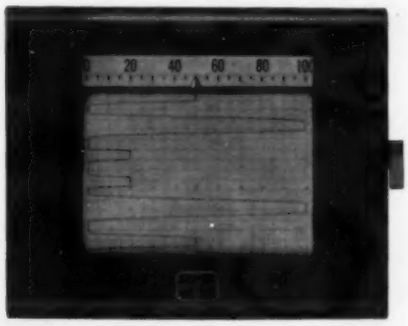
The excitation coil gives reliable long-life service. All insulating materials have been selected to withstand high temperatures encountered under continuous operation. Class B insulating materials, such as mica, fibreglass, and asbestos are used throughout, since they contain a minimum of organic binders in accordance with AIEE standards. High dielectric strength results in maximum electrical resistance to ground under all operating conditions.

Several models of SM Magnets are available. These vary from Model SM20 with an effective range of 6 in. at a belt speed of approximately 200 fpm, up to the largest Model SM60 with an effective range of 19 in. at a belt speed of approximately 500 fpm.

RECORDER

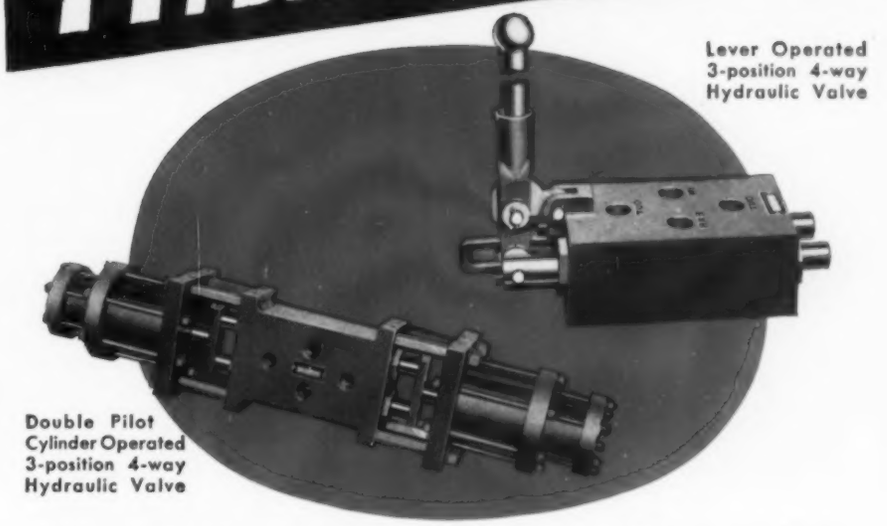
▲ Announced by the Bristol Co. is a recording wide-strip potentiometer which features full-scale pen travel in 0.4 sec.

The pen of the high-speed elec-



tronic dynamaster recorder makes the traverse across the 11 in. chart scale in 0.4 of a second without overshoot at the end. The "deadband" of the instrument is less than 0.1 per cent of the full-scale span. It is offered with standard ranges as low as 1

Quick-As-Wink®
HYDRAULIC VALVES

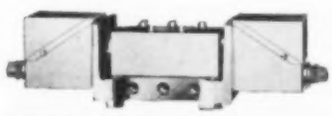


Hand and Pilot-operated Types for Water or Hydraulic Oils to 5000 psi.

• Quick-As-Wink Hydraulic Control Valves meet the most exacting requirements. These valves are fully balanced in any position. Patented design includes hydraulically balanced U-packers. Packers are floated while crossing the valving ports, thus assuring long life, and expanded by internal valve pressure to provide a tight seal. Maintenance is extremely low and usually can be done quickly in the field, avoiding the delay of returning valves to the factory for servicing, or the need of maintaining large standby inventories. For long, dependable, trouble-free service, specify Quick-As-Wink Hydraulic Valves. Write for Bulletin No. 531 and the fully descriptive Data Sheets. They give complete details. Write *today!*

Ask us also about . . .

CAM OPERATED SINGLE PLUNGER VALVE ⅜" to ¾" sizes. Operated by rotating cam or land on reciprocating device.



DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1928 East Pershing St., Salem, Ohio

Specify Adalet for

Vapor-tight Fixtures

With The Guard You Just Lift And Twist To Install

These Bayonet-Lock cast aluminum guards are just one of the many "extras" you get when you specify Adalet Vapor-tight fixtures.

Four tapped hubs and three plugs are standard.

Available with reflectors in sizes up to 500 watts... *complete fixture package in one box.*

Send for Bulletin E

Name _____

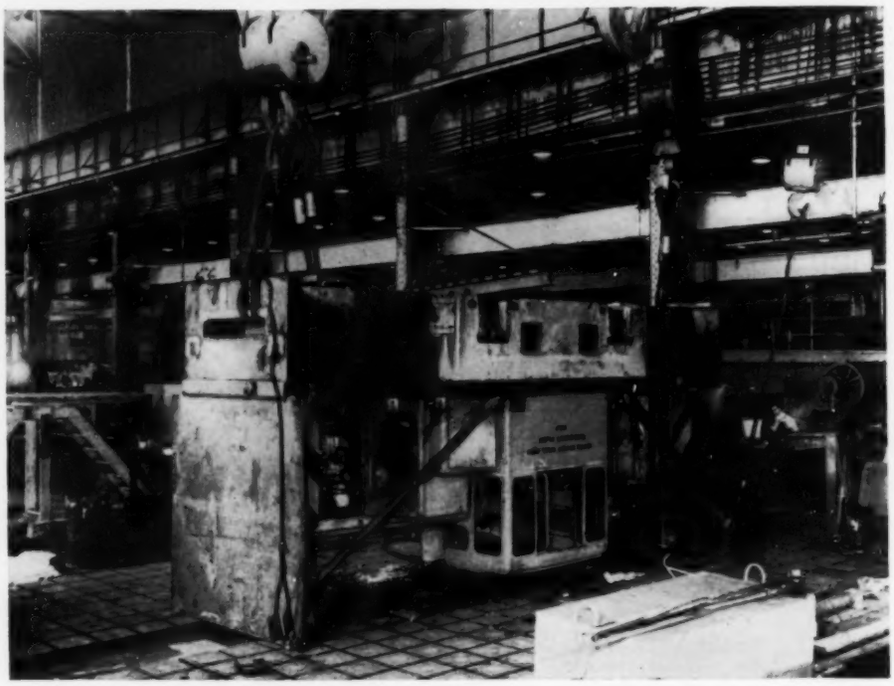
Title _____

Company _____

Address _____

THE Adalet MFG. CO.
5300 LORAIN · CLEVELAND 11, OHIO

LOCOMOTIVE GIVEN OVERHAUL AT GE



Part of an overhauling operation at the General Electric Co.'s locomotive and Car Equipment Dept., is a locomotive weighing 50 tons. Owned by the Vandergrift plant of the United States Steel Corp., this industrial switcher had been originally built for operation on narrow gage track. Part of the overhaul consisted of converting it for operation on wide gage track. The easiest method to do this was to turn the locomotive completely up-side-down. This way, two-thirds of the equipment still inside the locomotive did not have to be removed. Used by General Electric only for widening the gage of a locomotive, the method has proved very practical because the workmen can work on the underpart of the locomotive without the obstruction which would be encountered if the locomotive remained right-side-up.

millivolt for full-scale, with source resistance up to 10,000 ohms.

The high-speed recorder has proved highly useful for recording rapidly changing variables such as those encountered in rocket and jet-engine testing, wind tunnel investigations, and laboratory tests. Charts speeds up to 4 in. per second are offered. A specially designed recording pen and pen carriage are used to assure continuous inking at the high speeds, and to prevent damage when the pen comes to the end of the scale.

A voltage regulator is used in the field circuit of the feedback damping generator to provide constant damping voltage, regardless of line voltage variation. The amount of damping is adjustable, as is the amplifier-gain setting.

MAGNETIC BRAKES

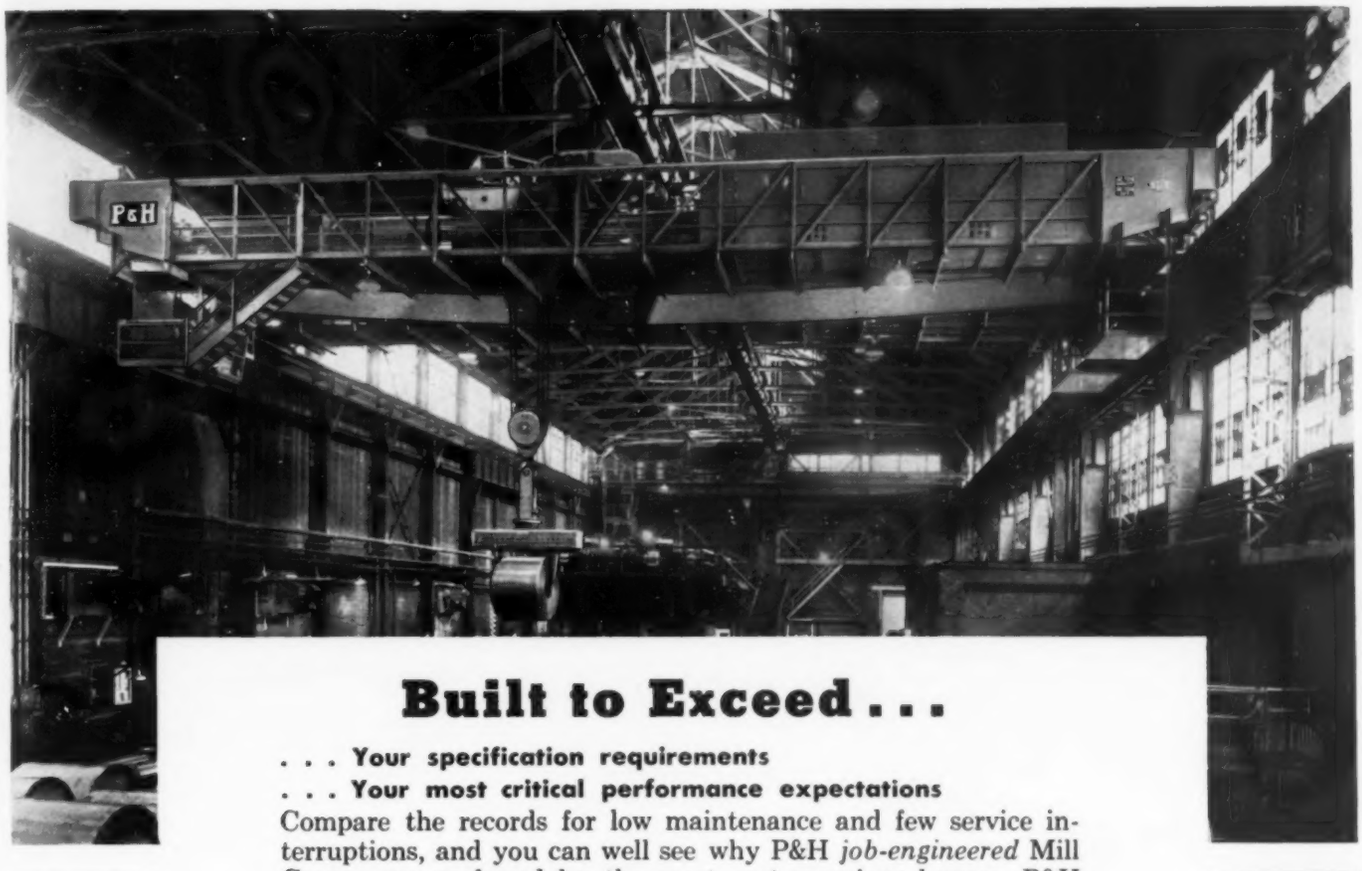
▲ Stearns Magnetic, Inc. has introduced a new H Style 1000 Series magnetic brake for use in the 25 to 50 hp range with both the old and newly re-rated NEMA frame sizes.

Improved mechanical design enables the new brake to develop higher torque and yet take up less space. It requires up to 6 in. less clearance for housing removal than the old style brake it replaces. Overall length has been reduced as much as 2¼ in. and weight reductions of more than 20 per cent have been effected. Two sizes are available which are rated at 125 lb ft and 175 lb ft torque. This brake may also be supplied for floor mounting.

LIGHT PANEL

▲The first fiberglass-reinforced daylighting panel to be listed by Underwriters' Laboratories, Inc., and to carry the Underwriters' label is being manufactured by the Resolite Corp., Zelienople, Pa., under the trade name of "Fire-Snuf."

These panels have a flame spread rating of below 75. This is equivalent



Built to Exceed . . .

. . . Your specification requirements

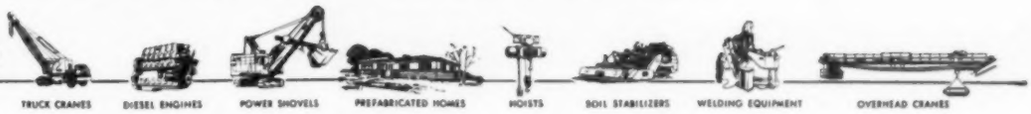
. . . Your most critical performance expectations

Compare the records for low maintenance and few service interruptions, and you can well see why P&H *job-engineered* Mill Cranes are preferred by the most cost-conscious buyers. P&H Overhead Crane Division, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

P&H MILL CRANES

HARNISCHFEGER

the P&H *Line*



CM Hammerlok®

COUPLING LINK

Greatest Chain Development of the Day!

A typical Herc-Alloy chain assembly made up with Hammerlok coupling links.

NO PEENING
NO WELDING

The Hammerlok link is securely locked by the alloy steel pin which bites deeply into the tubular stud. The locking arrangement is hidden and inaccessible.

NOW... you can make up Herc-Alloy chain assemblies yourself... with economy, speed and SAFETY.

HAMMERLOK FEATURES

- **SIMPLE ASSEMBLY**—Expert help is unnecessary. This link can be properly assembled by anyone who can drive a nail.
- **RUGGED DESIGN**—The Hammerlok link has been thoroughly field tested. It withstands the severe usage to which alloy chain is so often subjected.
- **GREAT STRENGTH**—Hammerlok links are stronger than Herc-Alloy chain.
- **RE-USEABLE**—Hammerlok links can be disassembled and re-used.
- **NO WORRY**—The human factor plays no part in the assembly or safety of this link, since skill is not required in its assembly.

A BOON TO CHAIN BUYERS AND USERS

No longer do you have to wait for custom made (or repaired) alloy chain assemblies to reach you from the factory. Now you (or your distributor) can stock assorted sizes of Herc-Alloy chain and attachments... plus an assortment of Hammerlok links. Then, when you need a new or rebuilt alloy chain assembly, it can be made up in a jiffy.

- ***Ask your distributor about Hammerlok coupling links today.***
- ***Write for folder describing use and assembly in detail.***

NOTE Hammerlok coupling links are NOT sold as repair links for body chain. When the body chain in an alloy chain assembly requires repair, the entire section of chain should be replaced or the complete assembly returned to the factory for reconditioning. Hammerlok links ARE recommended for replacing complete sections.

Made by the makers of HERC-ALLOY—the original alloy steel chain

CM HOISTS AND CHAIN

COLUMBUS McKINNON
CHAIN CORPORATION
TONAWANDA, NEW YORK
DISTRICT OFFICES: NEW YORK, CHICAGO, CLEVELAND

In Canada: McKINNON COLUMBUS CHAIN LIMITED, ST. CATHARINES, ONTARIO

to the Building Officials Conference of America (BOCA) classification of "slow burning" and means that they meet the safety requirements for most factories and other coded areas. By comparison, the rating for plastic wall tile is 170, for cellulose board 255, and for veneered woods above 500.

The panels are self-extinguishing and will not support combustion. They are molded of fiberglass and Hetron, a permanently self-extinguishing polyester resin, manufactured by Hooker Electrochemical Co. Under the heat of a blow-torch these fire resistant panels will ignite, but they extinguish themselves almost immediately upon removal of the source of heat and flame.

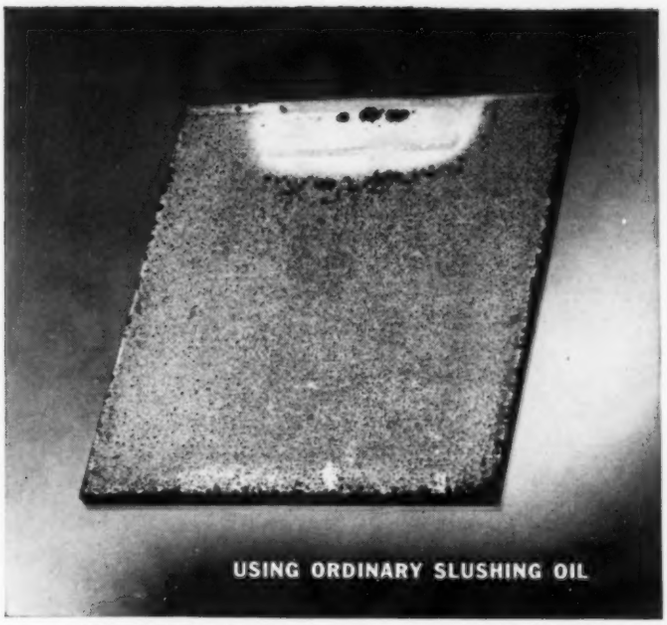
TRANSFORMER

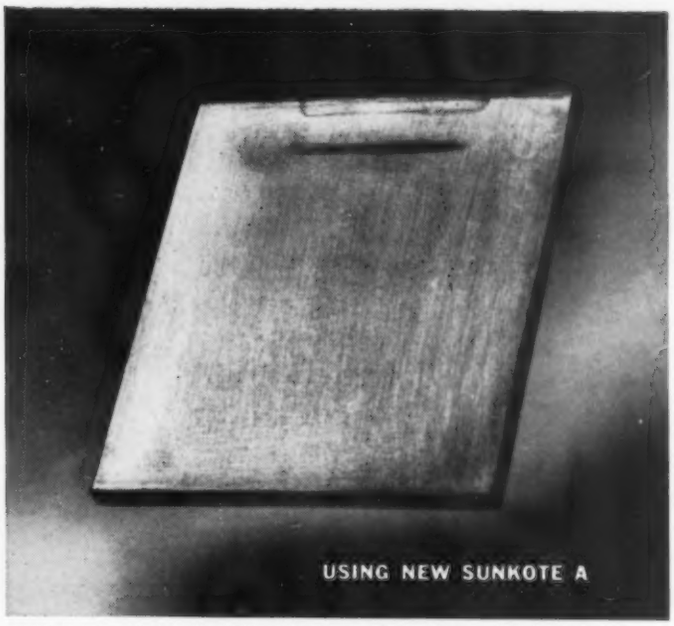
▲ Pennsylvania Transformer Co. has designed and manufactured a 500 kva, 13 kv, three phase, subway-type network transformer for the Consolidated Edison Co. of New York, that incorporates such features as low overall height, easy-to-maintain tank, suspension mounting, and quiet operation.

Everything about the tank construction is functional, from attaining maximum cooling to simplifying the problem of maintenance. Everything on the tank can be reached for cleaning from any position on top of the tank.

The two sides of the tank are each fashioned in eleven equal corrugations that replace conventional radiators or tubes and provide the required amount of radiating surface for cooling the insulating liquid. In addition to making inspection and cleaning relatively easy, the vertical corrugations allow the transformer to be thoroughly painted in the field by either brush or the flow method. There is no place on the tank that cannot be reached for complete inspection or cleaning. Vertical corrugations, in place of radiators, eliminate ledges and crevices where dirt could collect. Lift lugs are located at the four corners of the tank in order not to interfere with the cleaning process.

The transformer tank is only 50 in. in height and is provided with brackets for suspension mounting of the transformer in a manhole. These transformers can also be supplied





Humidity Cabinet Test proves superiority of new coating oil. Using ordinary slushing oil, steel test panel (on left) shows harmful rust after only 100 hours in humidity cabinet with relative humidity of 100% at 120 F. An identical steel test panel (above right), protected by new Sunkote A, shows no rust or stain whatsoever after 200 hours under same rust test conditions of high humidity and temperature.

ANNOUNCING SUNKOTE A

a new, low-cost rust preventive coating for hot and cold rolled strip and sheet steel

SUNKOTE A is easily applied by dip, roller, or spray. Special compounding provides extra protection against rust and stain at lowest cost.

Sunkote A is specifically compounded to protect hot and cold rolled strip and sheet steel against rust and stain for long periods in storage and in transit.

Economical to use, Sunkote A is moderately priced... gives maximum coverage and protection... can be applied by all usual methods... is easily removed by any of the normal cleaning processes.

For complete information about this new product, see your Sun representative...or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-9.

SUNOCO®

INDUSTRIAL PRODUCTS DEPARTMENT

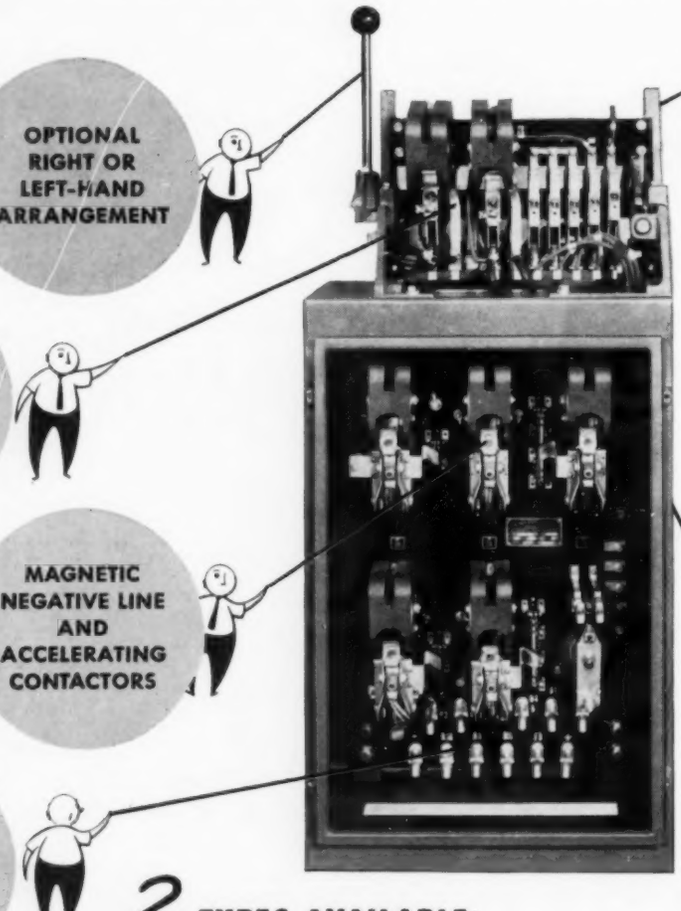
SUN OIL COMPANY Philadelphia 3, Pa.

IN CANADA: SUN OIL COMPANY, LTD., TORONTO AND MONTREAL

NEW

HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

Combination Manual and Magnetic Controller for Cranes . . . Charging Machines . . . D-C Control Jobs



OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT

CAM SWITCH CAN BE MOUNTED REMOTE

HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION

COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM

MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS

MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE

TOE SPACE FOR OPERATOR'S COMFORT

2 TYPES AVAILABLE:

REVERSE-PLUGGING OR DYNAMIC-LOWERING

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.

*PATENT APPLIED FOR

Ask for Bulletin 4400-4401.

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
EUCLID
AND MFG. CO., MADISON, OHIO

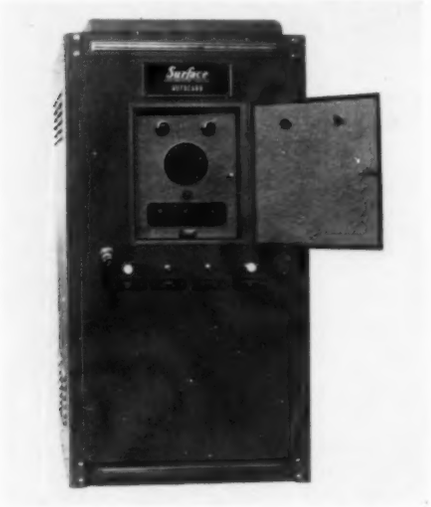
with pedestals for installing the transformer up off the floor of the vault. Standard NEMA tests indicate the transformer to be unusually quiet.

Transformer coils are of the continuous pancake design. A new grounding switch introduced with this transformer assures easy mechanical operation.

The two-coil construction is available in a variety of widths and diameters ranging from 12 in. to 60 in.

CONTROLLER

▲ Surface Combustion Corp. has announced a new automatic carbon potential control instrument for controlled atmosphere heat treating.



This new controller provides a simple and economical means of automatically controlling the dewpoint and, hence, the carbon potential of a heat treat furnace atmosphere. It is applicable to processes such as gas carburizing, cleaning hardening, etc., where a permanent record is not required.

PULLEY

▲ Stearns Magnetic, Inc., has announced a new two-coil electro-magnetic pulley which removes more tramp iron than larger units on many conveyor operations.

It is claimed that the new two-coil design produces a more effective flux pattern with a deeper magnetic field at the center of the pulley—a pattern which conforms to normal conveyor load conditions. In many applications it is possible to install a two-coil pulley of smaller diameter than a three-coil pulley handling the same job, thus reducing both equipment and power costs with no decrease in tramp iron protection.

PUSHTHROUGH PRESS

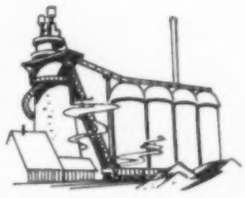
▲ Installation has been completed on the 3000 ton "pushthrough" press, now in production at the Colorado Fuel and Iron Corp.'s Wickwire Spencer Steel plant. The giant press is capable of producing heads up to 10 ft in diameter.

The press is capable of exerting a maximum force of 6,000,000 lb. Specially designed for CF&I by the Verson Allsteel Press Co. the press stands 68 ft from top to bottom of pit.

LAWRENCE

BLAST FURNACE TUYERES

save TIME . . . and MONEY



Lawrence Tuyeres are true in shape, fit smooth and snug into the cooler without machining.

Lawrence has served many of America's large steel mills continuously since 1888. Such customer satisfaction is the result of highest quality and complete dependability.

Next time . . . specify Lawrence. You'll save both time and money.

PURE COPPER CASTINGS

Tuyere Coolers • Bosh Plates
Mantle Plates • Cinder Notches
Valve Gates and Seats

HEAVY TYPE (1 to 2 ton)
BRASS AND BRONZE CASTINGS

Bearings
Machinery Bronze
Bars and Bushings

LAWRENCE COPPER & BRONZE CO.

ZELIENOPLE, PA.

BOX 246 PITTSBURGH DIST. PHONE 774

fast*
sure*
safe*

*three ways to describe Salem-Brosius clay guns in operation at the blast furnace tap hole. For more than three decades our engineers have diligently applied their experience to the design and production of efficient low-cost guns. That's why so many Salem-Brosius guns have been working so long—so well. Available mechanical, hydraulic, or steam—pedestal or column mounted. For fast, sure, safe guns—please write to us.

SALEM-BROSIUS, INC.
Arch Street, Carnegie, Pa.
In Canada: Salem Engineering Ltd.
1525 Bloor Street West • Toronto 9, Ontario

After the pressing operation, the finished heads are carried from the pit to ground level by an automatic conveyor. This unique feature of the new press is designed to simplify and speed up handling, and the entire operation is completely automatic from loading to finishing.

Virtually any metal can be worked in the new press. At present, the press is equipped only for cold-forming, but a new heating furnace now under construction at the plant will enable the press to perform either hot or cold press operations.

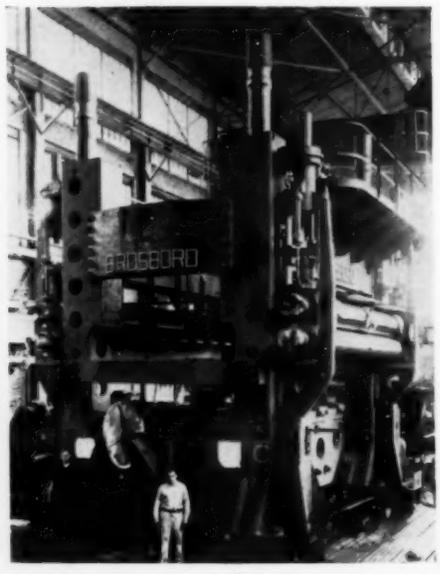
ARCWELDING

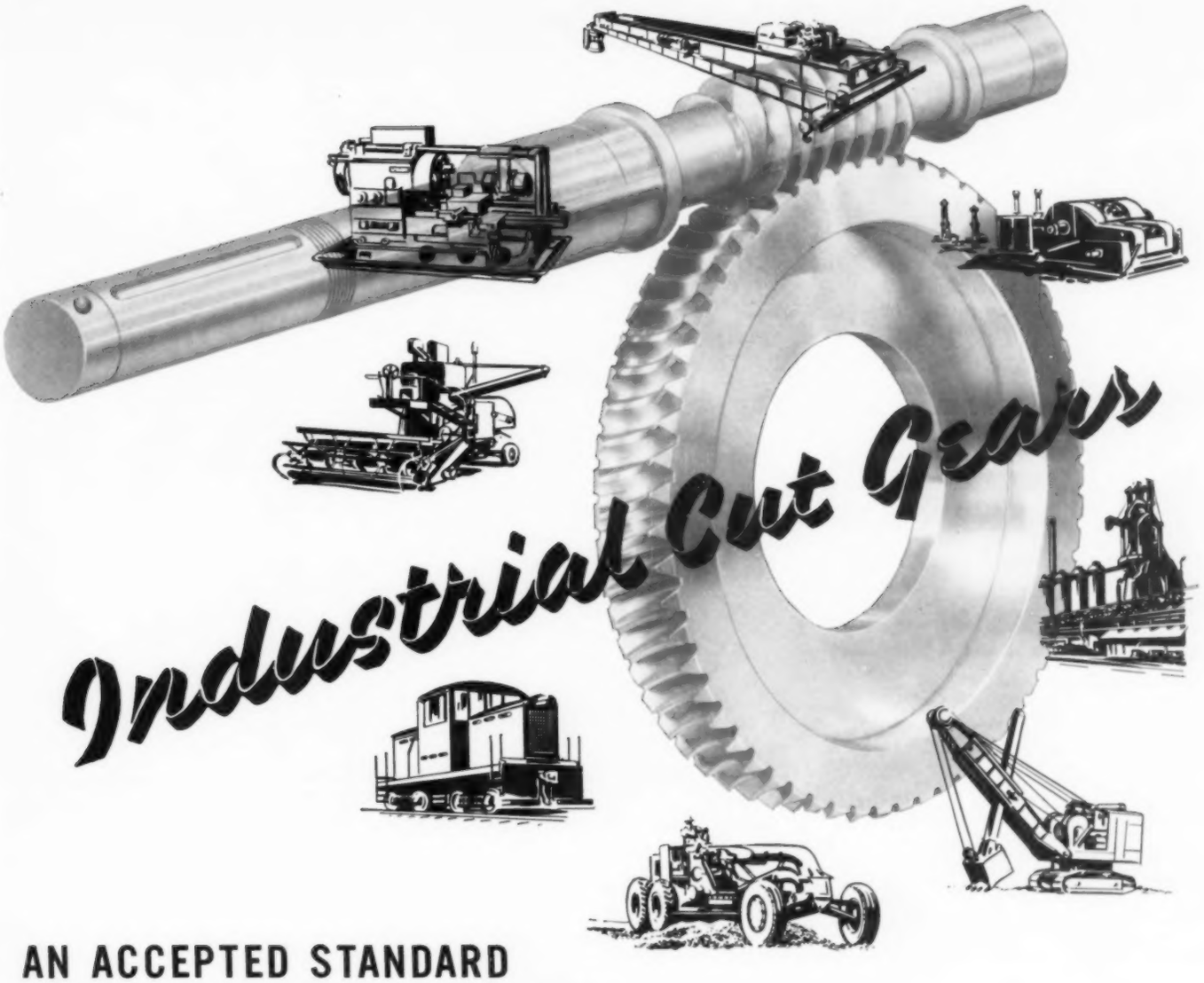
▲ The new Airco 800 Ampere TCV Rectifier arcwelder is designed expressly for inert gas shielded consumable electrode welding. Introduced by Air Reduction Sales Co., this machine features constant arc voltage for all automatic machine welding applications employing constant speed wire feed.

This new arcwelder contains a three phase transformer and a rectifier bank. Coils are aluminum wound, silicone and glass insulated, for lightness and protection against high temperatures and moisture. Forced draft cooling is provided by a fan with a reversible ball bearing motor.

PLATE LEVELLER

This giant leveller handles cold armor plate up to 2 in. thick and 200 in. wide at Lukens Steel Co. Built by the Birdsboro Steel Foundry & Machine Co., the leveller is adaptable to handling a wide range of plate widths and thicknesses. Nine work rolls are used on plate up to 1¼ in. thick. Four rows are hydraulically retracted for greater thicknesses.





Industrial Cut Gears

AN ACCEPTED STANDARD FOR THE NEEDS OF INDUSTRY

Behind "Industrial" production you'll find modern equipment . . . engineering skill . . . craftsmanship . . . constant control . . . and large capacity.

We are specialists in cutting Gears, Sprockets, and Racks to serve machinery and equipment builders in all fields. Always specify "Durocase" Gears for Heavy-Duty or Steel Mill Service.

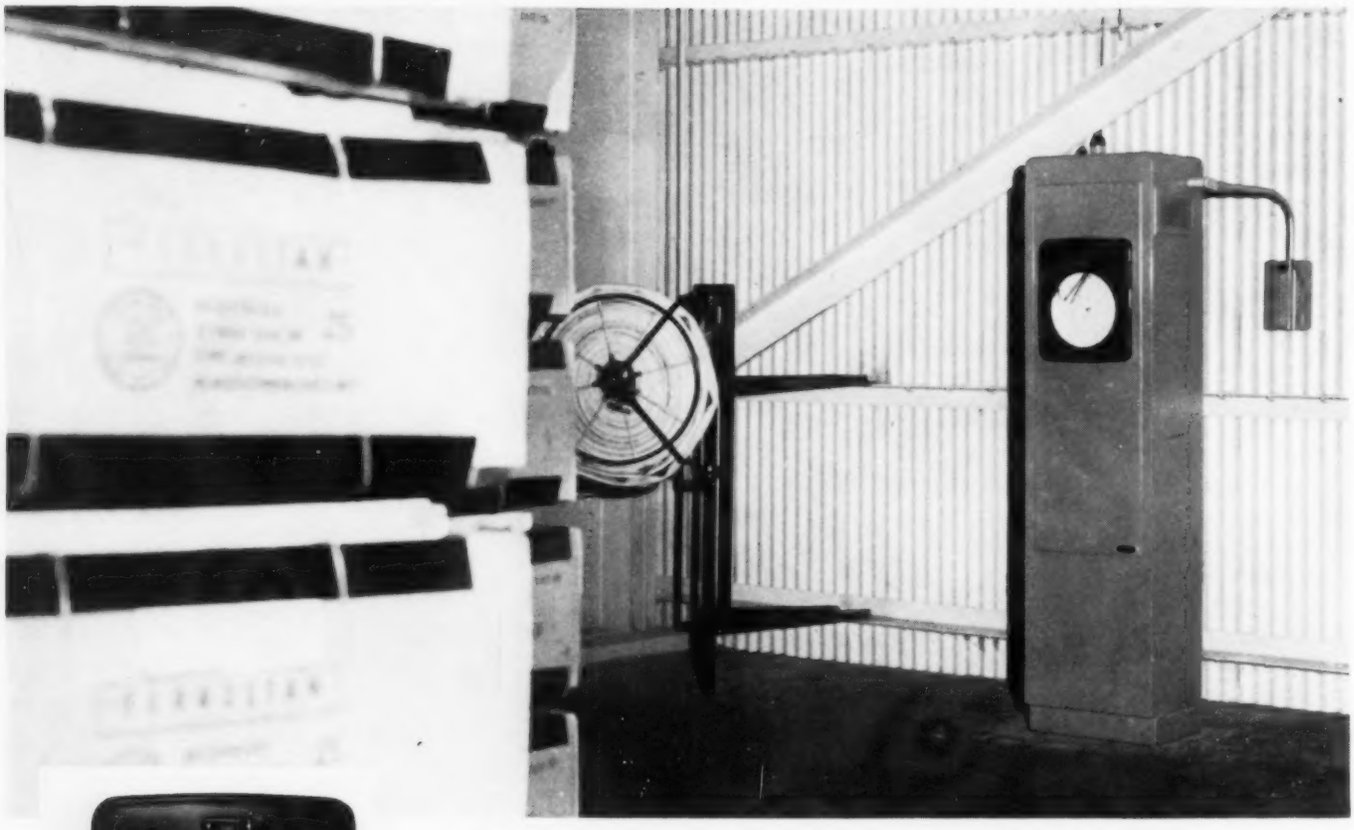
The quality we offer keeps assembly and maintenance costs low and assures dependable performance under the roughest conditions.

Send us your specifications for a prompt quotation on your requirements. Also write for Brochure "A Pictorial Trip Through Industrial."

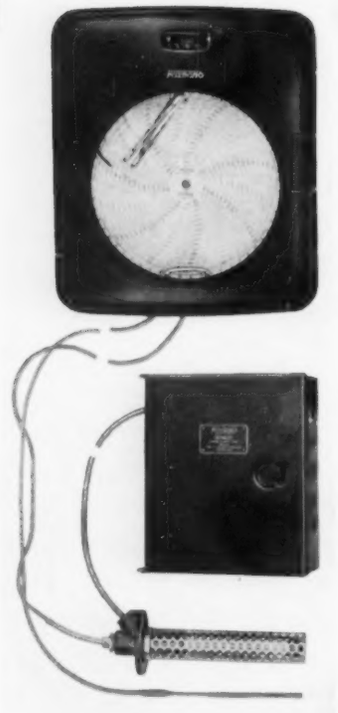
Industrial Gear Mfg. Co.

4527 W. VAN BUREN ST.
CHICAGO 24, ILLINOIS

Don't let steel sweat!



One of three "package unit" Foxboro Condensation Prevention Controllers which continuously guard storage areas in a large eastern steel plant.



. . . prevent moisture damage to stored steel with Foxboro Control

Steel in storage stays dry, resists rust and corrosion, when it's protected by a Foxboro Condensation Prevention Controller. This simple, inexpensive Controller automatically makes sure that air temperature in the storage area is always high enough above the dew-point to prevent costly condensation.

The Foxboro Condensation Prevention Controller employs the exclusive Dewcel* element to measure dew-point, and a dry bulb element to measure temperature. Control action automatically energizes signal devices, or operates valves in the building's heating system to hold air temperature safely above condensation point.

Operation of the Foxboro Condensation Prevention Controller is equally effective from 0° to 120°F. dew-point. It requires no water box or circulation of air — no air sample refrigeration under normal conditions. And there's practically no maintenance. Protect *your* sheets, rolls, and similar materials this modern, economical way. Write for Data Sheet 000-8 or call your nearest Foxboro Field Engineer.

* "Trademark"

← Controller (top) continuously measures and records dew-point. Dewcel "sensing" element (bottom) functions equally well in still or moving air. Instrument in center is Dewcel power unit.

THE FOXBORO COMPANY, 589 NEPONSET AVE., FOXBORO, MASS., U. S. A.

FOXBORO
REG. U. S. PAT. OFF.

CONDENSATION PREVENTION CONTROLLERS

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

This reversing feature allows dust and lint to be blown from the rectifier stack.

With this machine the arc voltage may be pre-set over a wide range, from 15 to 44 arc volts. The voltage may also be pre-set to provide a higher initial voltage for ease in establishing the arc. Once the arc is established the voltage automatically adjusts to the pre-set value. This arc voltage then remains constant regardless of load conditions or changes in input line voltage.

RADIATION DETECTOR

▲ A new high-speed radiation detector five times faster than existing models has been developed by the Industrial Division of Minneapolis-Honeywell Regulator Co.

The new unit, an addition to the firm's line of "Radiamatic" radiation pyrometers, responds to 98 per cent of any temperature change in less than a half-second. The temperature measurement can be accomplished without actually making physical contact. It is especially suited for temperature measurement of fast-moving bars, billets and sheets which are "on target" for less than a second. It is also designed for applications where profile measurements determine temperature distribution along a moving slab, strip or sheet.

There are three models of the new high-speed unit available. One has a narrow sighting angle (20:1 ratio) for intermediate temperatures, covering the range from 800 to 1900 F. Other models have either a narrow angle (20:1 ratio) or a wide angle (7:1 ratio). Both cover the high temperature range from 1000 to 2600 F.

The units are calibrated under black body conditions and are compensated for ambient temperatures to 250 F. A complete line of accessories is available.

PLATFORM SCALE

▲ Electrical weighing with automatic control of flowing powdered materials in hopper carts is the first application of a new floor-level platform scale announced by Baldwin-Lima-Hamilton Corp. These new scales of 500 lb capacity can be set in a pit 10½ in. square and less than 12 in. deep.

A variety of instrumentation can be used with the scale, including indicators, recorders, and control equipment. Lamps will indicate predetermined weights on each scale at which material feed valves will be turned off automatically. The dial indicator can be switched to any scale circuit.

The new electrical platform scale incorporates a single Baldwin SR-4 Load Cell of compression type in which SR-4 bonded resistance wire strain gages are the load sensing elements. The cell supports a platform on a short column which is held vertical by two sets of radial flexure straps. Accuracy of weight is thus assured by permitting only vertical application of load regardless of the location of the load on the platform.

Principal advantages of electrical weighing are centralized, remote indications of loads and simplicity of use in an automatic control system. Extremely low power output with remote electronic amplification is a safety feature.

LIFT HOIST

▲ The Symington-Gould Corp. of Depew, N. Y., has recently developed a new method to make maintenance of overhead cranes a safer job.

An Ingersoll-Rand long lift hoist was mounted on a jib boom above the crane runway. The hoist is moved along the boom, by a hand operated chain drive, and the jib boom is rotated through a hand chain and gearing arrangement. This installation enables the workmen to handle the heavy crane traction motors and the truck or trolley parts from the wide supporting walkway.

The parts to be repaired can safely and quickly be lowered or raised from floor level 56 ft below, which reduces the hazard when making replacement of crane parts. Also eliminated is the peril and heavy work of installing temporary long lift chain hoists high above the floor level.

In addition to greatly increased safety, the installation of air hoist and jib boom reduced the maintenance burden of the operation.

BALL BEARINGS

▲ A new series of ball bearings designed for medium duty service conditions has been added to its 30,000 hour line by the Dodge Manufacturing Corp. Designated as SCM Ball Bearings, they provide more load-

cut down shutdowns..

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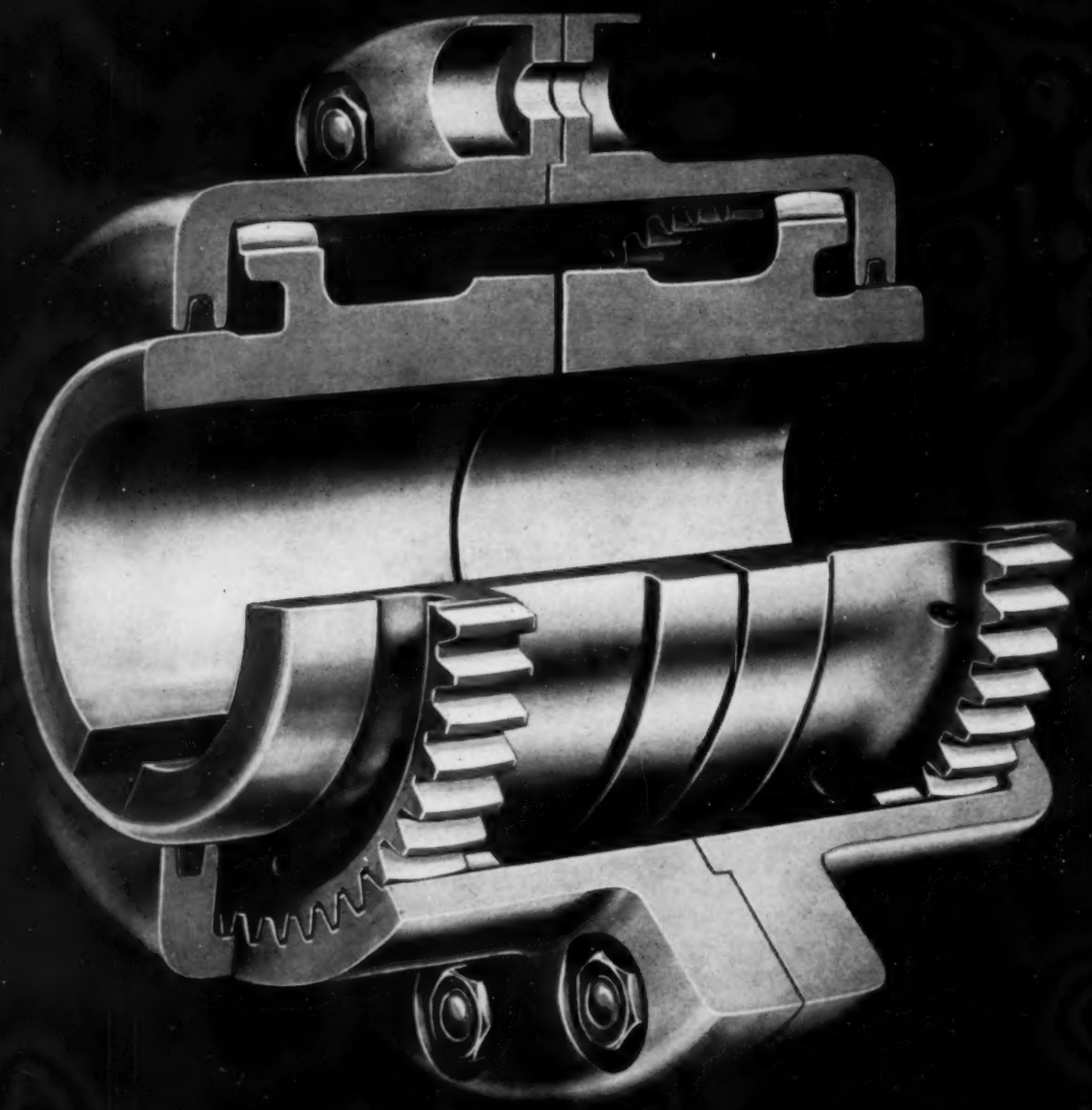

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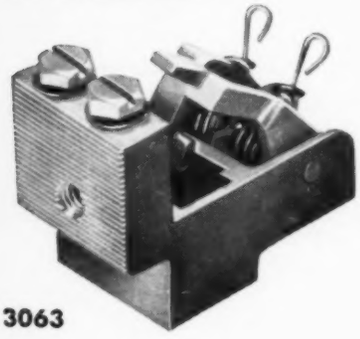

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FLOWER PHILADELPHIA

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carrying capacity and are available in larger shaft sizes. The new line includes both ball bearing pillow blocks and ball bearing flange cartridge mounts.

The rugged semi-steel outer housing of the pillow blocks provides greater strength with trim, streamlined appearance. Full self-alignment is provided by the spherical outer race of the ball bearing inner unit, which fits accurately into the spherical seat in the housing.

Metallic backed synthetic seals are mechanically anchored in position and will not blow under grease gun pressure. The lubricant is effectively sealed in; dust and dirt are excluded. A locking pin prevents rotation of the outer bearing race while allowing full self-alignment. The bearing is securely locked to the shaft by means of two set screws through the collar at 120 degrees.

The bearings are completely assembled, factory adjusted, pre-lubricated and ready to mount on the shaft.

LEAD PATENTING

▲ A new means of lead patenting carbon steel rods has been developed that minimizes lead loss and eliminates oxidation on the surface of the lead bath. Lead costs alone have been cut by more than half.

Both problems were solved in a steel mill recently by insulating the lead bath with a blanket of specially compounded heat treating salts and mesh charcoal.

The mill consulted E. F. Houghton & Co., and the following procedure evolved:

First step toward eliminating the lead loss was to clean all the lead oxide from the surface of the kettle. The sides and top were scraped clean. Then Houghton's Liquid Heat 636, a specially compounded salt, was added to a depth of about one inch. This salt melts to form a liquid blanket on top of the lead surface. By sealing off the air it thus prevents oxidation of the lead.

It was found, however, that the bare liquid salt radiated so much heat that the furnace had to fire hard continuously to keep the temperature up. To counteract this condition and hold the heat in, the salt was covered with a No. 3 mesh charcoal.

The charcoal coating made the salt layer freeze and form a hard crust.

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says—VANADIUM-ALLOYS STEEL CO.

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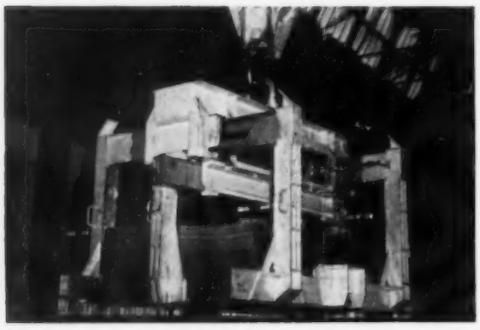

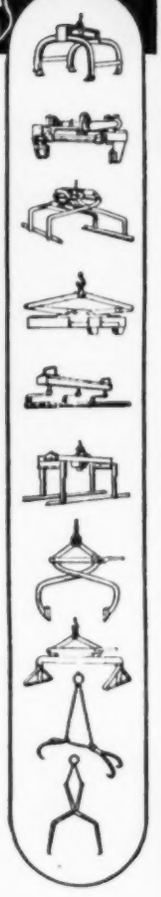

Sheet widths from 24" to 72" and lengths from 72" to 168" are handled by this **one** Mansaver Grab, Style G-1456. Motor-driven side arms and patented motor-driven end hooks give safe, all-round support, permitting lifts of 30 tons and more.

Manucl, motor-driven, or automatic, **large or small,** Mansaver Grabs are engineered to fit the job and pay their way quickly, handling sheets, bars, or coils. Write for Catalog G-3 and name of our nearest representative, who will be glad to show how this applies to **your** plant.

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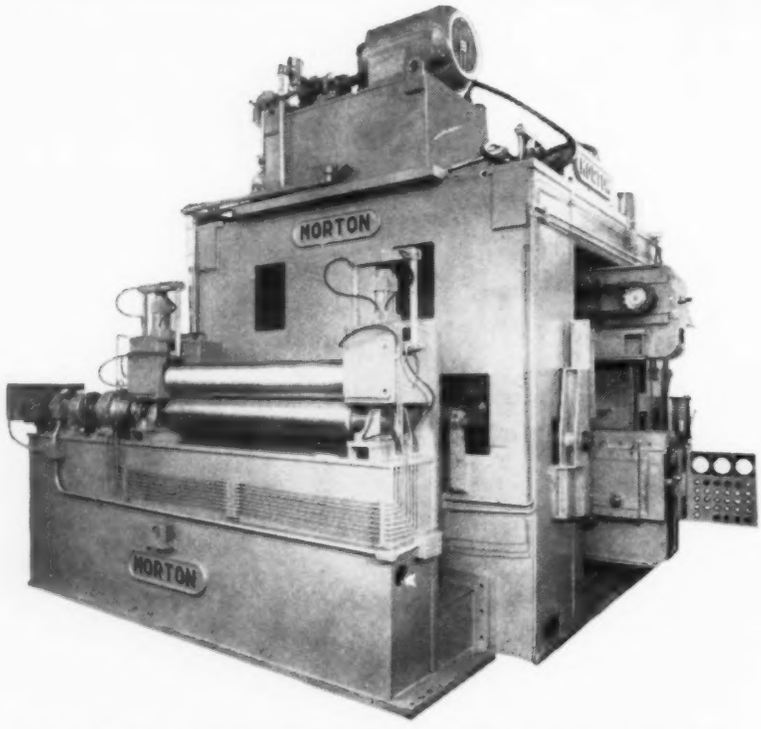
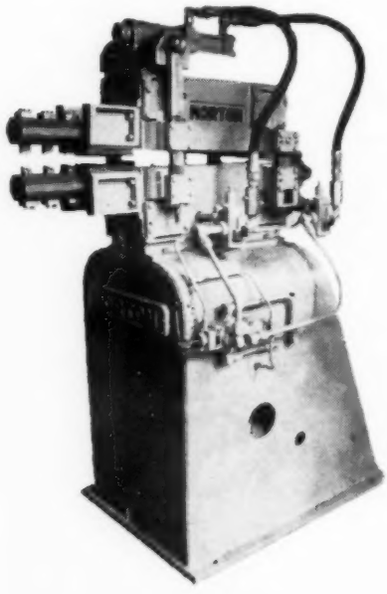


This Model RB is designed for joining the ends of coils in continuous process lines. Galvanizing, Pickling, Annealing and Slitting lines are some of the continuous processes requiring this Morton equipment.

A light duty floor or bench type trimmer having 4", 6" and 8" width capacity and ⅛" maximum metal thickness. Can be arranged for cylinders or strip trimming. When furnished with Morton Automatic Welding Equipment it is tops for many industrial applications.



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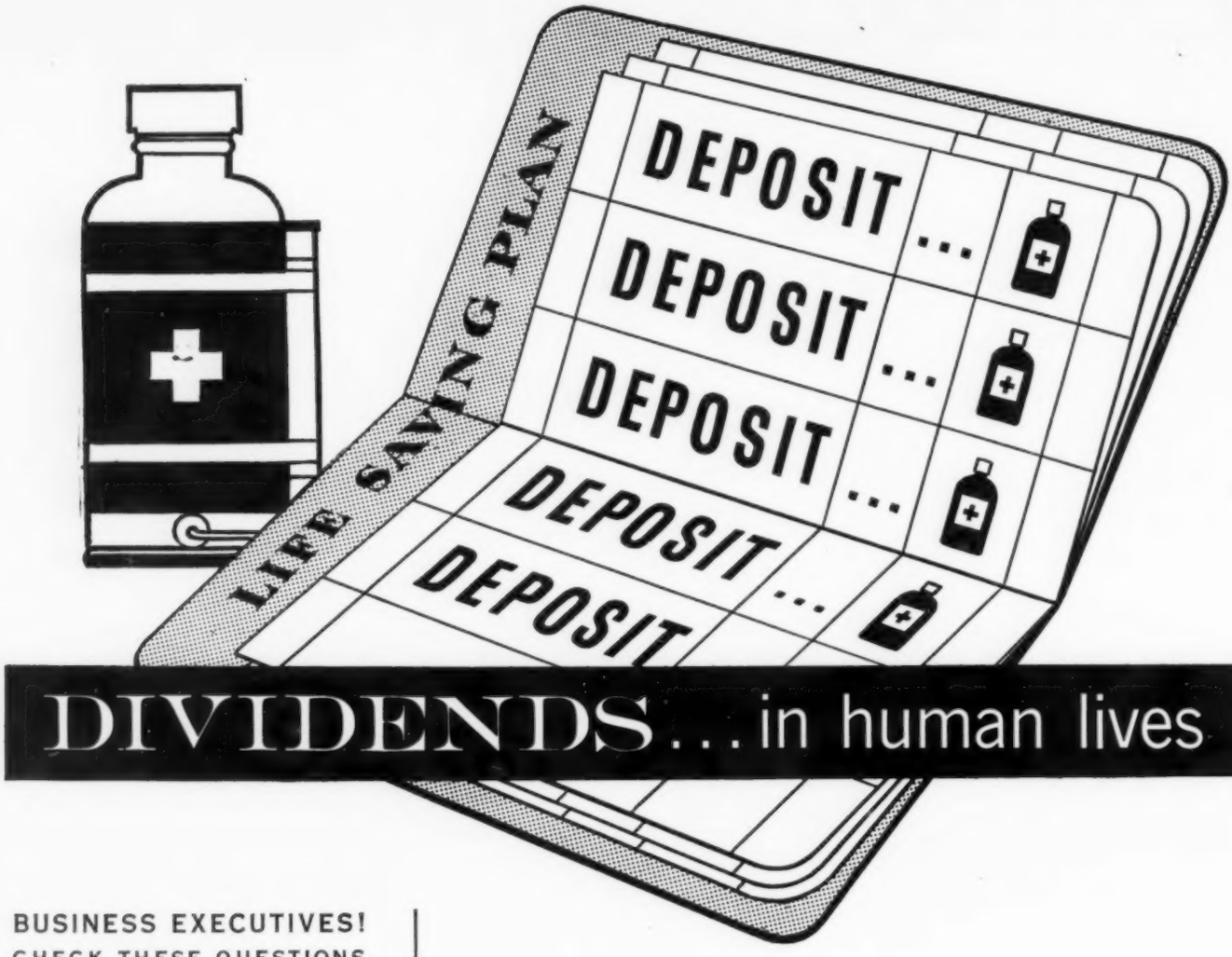

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America must give. America is **you**. Won't you call your Red Cross, Armed Forces or Community Blood Donor Center right now, for an appointment?

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Book Reviews . . .

"Electro-Technology," by M. G. Say, has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. It contains 167 pp., 5¼ × 8½-in., cloth bound and sells for $6.00. This book presents in concentrated form the electro-technical basis of the phenomena important in electrical engineering. The introductory section of this book deals with conduction and magnetic and electric field effects. The second part of the book includes a complete guide for handling circuit problems. It includes also a collection of theorems which are of help to those who have to work out electrical quantities in circuits and networks. This book can be used as a textbook for students and for reference by the practicing engineer.

"Transactions Bulletin No. 28" covering the "19th Annual Meeting —1954—Industrial Hygiene Foundation" has become available, and may be obtained from the Industrial Hygiene Foundation of America, Mellon Institute, Pittsburgh 13, Pa. It contains 239 pp., 6 × 9-in., and can be secured for $5.00. It presents the discussions and presentations at all the sessions including topics dealing with medical, legal, joint medical-legal, chemical-toxicological and engineering developments.

"Electric Arc-Welding Machines and Electrodes," NEMA Publication No. EW 1-1955, has recently been published by NEMA in the form of a standard. It covers the rating, testing and manufacture of d-c arc-welding generators and motor-generators, a-c arc-welding generators, motor-generators and transformers and rectifier-type arc-welding machines. This publication sells for $2.25 a copy from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

"Mercury-arc Power Rectifier Units," NEMA Publication No. 220-1955, has just been published by NEMA in the form of a standard and contains general standards, supplementary information and definitions for units such as electrochemical rectifier units, industrial rectifier units for ungrounded two-wire service, mining rectifier units, and transportation rectifier units. This can be purchased from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y. for $2.00 per copy.

"Shunt Capacitors," NEMA Publication No. CA 1-1955, is a standard recently published by NEMA containing information on the rating, manufacturing, testing, application and operation for capacitor units of ½ kva and larger for power factor improvement and other low-frequency a-c application, and assemblies of capacitor units with accessories and control to form complete capacitor installations. This standard costs $2.00 per copy, and can be obtained from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

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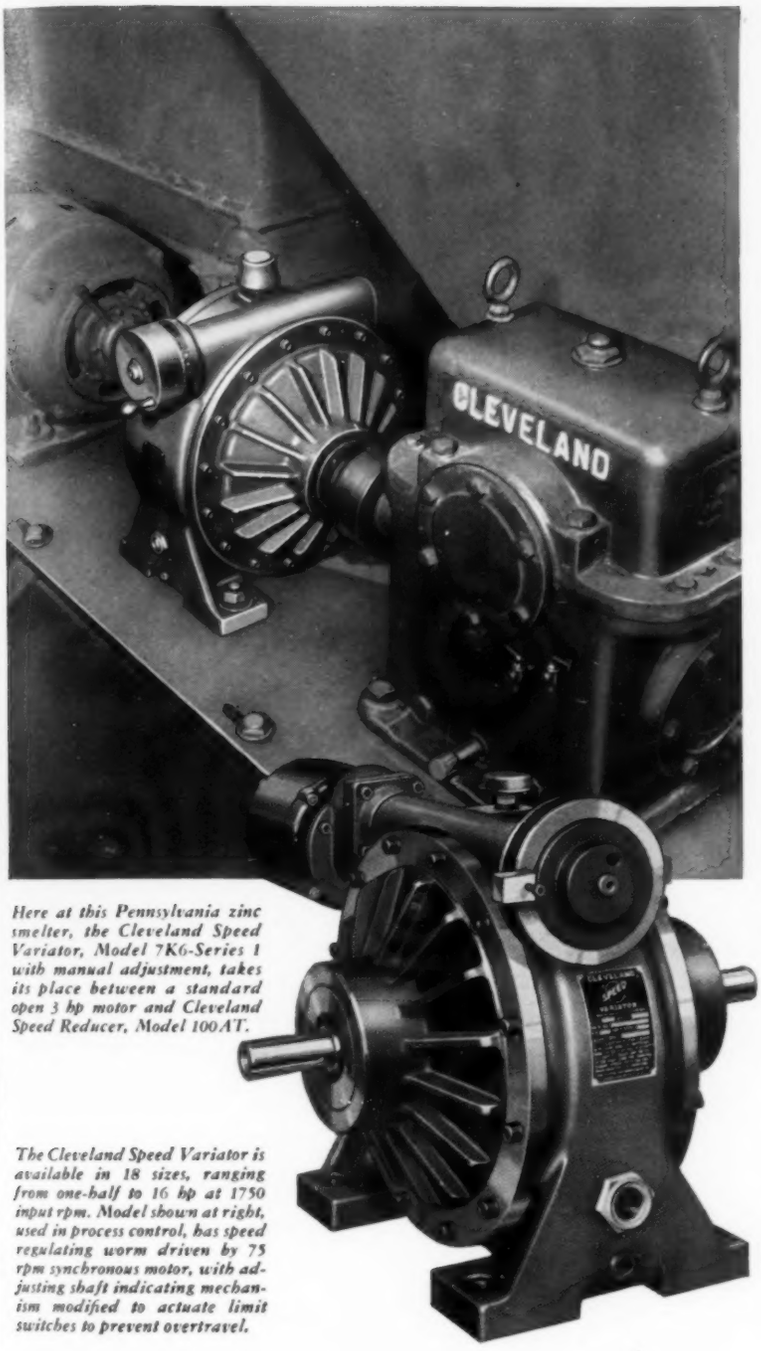

Here at this Pennsylvania zinc smelter, the Cleveland Speed Variator, Model 7K6-Series 1 with manual adjustment, takes its place between a standard open 3 hp motor and Cleveland Speed Reducer, Model 100AT.

The Cleveland Speed Variator is available in 18 sizes, ranging from one-half to 16 hp at 1750 input rpm. Model shown at right, used in process control, has speed regulating worm driven by 75 rpm synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

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4. Speeds infinitely variable over 9:1 or 6:1 range.
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7. Ample bearing support for overhung pulleys on either input or output shafts.

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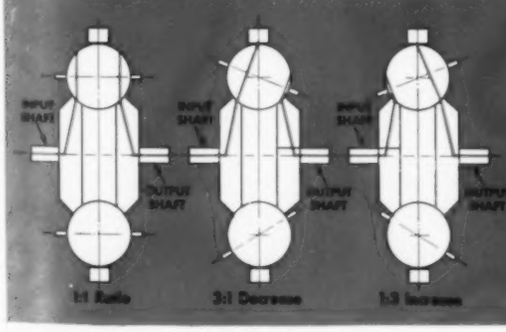
HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (see diagrams, left, and cutaway view, right).

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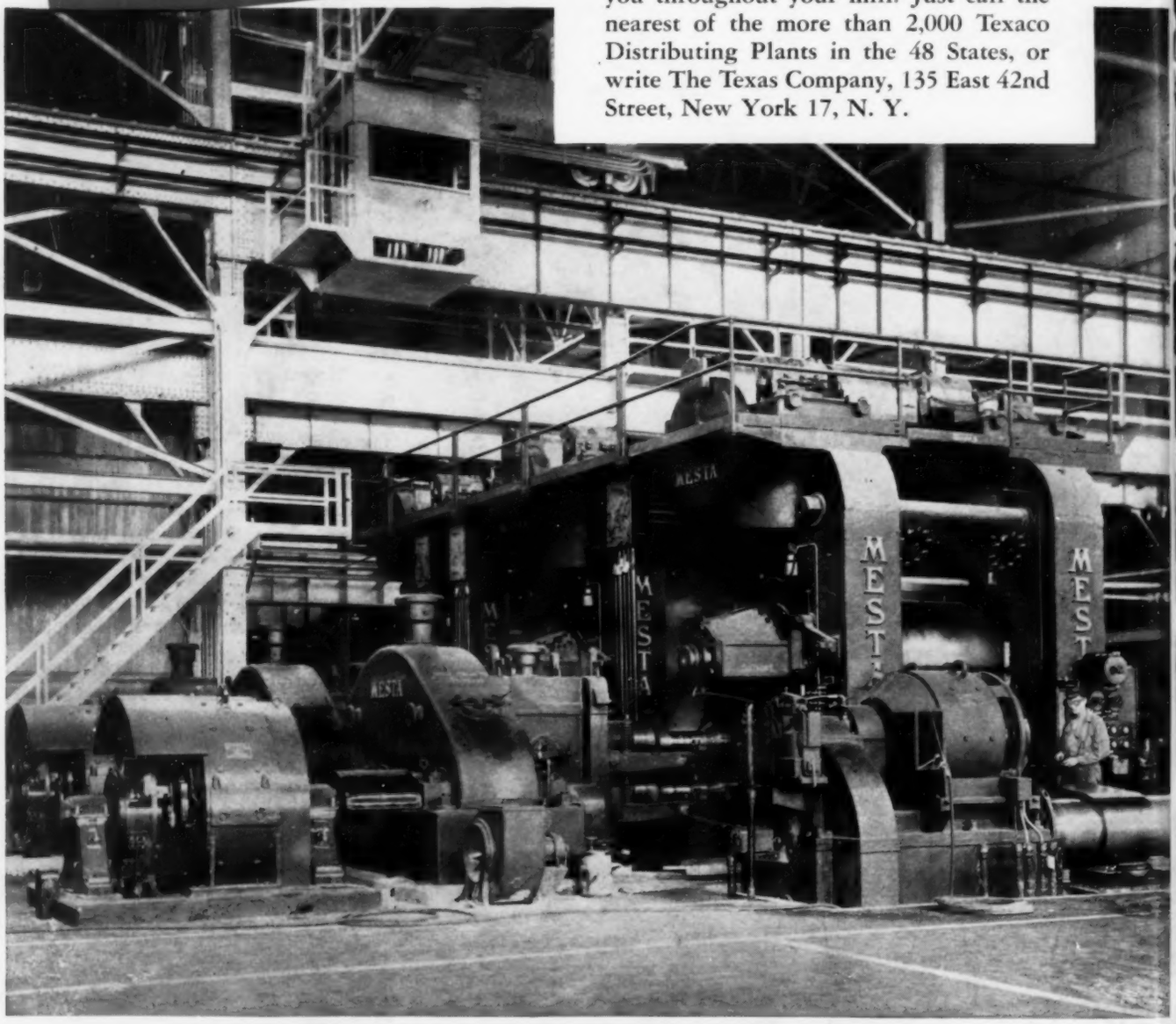

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